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POWER SYSTEM TECHNICAL DESCRIPTION

VAX11 780

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EK-PS780-TD-001

VAX-11/780 Power System Technical Description

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CHAPTER 1
INTRODUCTION

1.1 PURPOSE
This technical description provides all presently available information on the VAX-11/780 Power System. The purpose of this document is to provide DIGITAL field engineers, and/or customer personnel trained by DIGITAL's Educational Services, with an engineering-level understanding of power control and distribution within the system.

1.2 RELATED DOCUMENTATION
Table 1-1 lists available related documents.

Table 1-1 Available Related Documents

Title	Document No.	Notes
861-A,B,C,D,E,F Power Controller Maintenance Manual	EK-861AB-MM-002	Available on microfiche
BA11-K User's Guide	ED-BA11K-OP	Available on hard copy
BA11-K 10.5 Inch Mounting Box Technical Manual	EK-BA11-TM-003	Available on microfiche

1.3 SUMMARY DESCRIPTION OF POWER DISTRIBUTION SYSTEM
Centralized control of the ac and dc power within the VAX-11/780 systems is made possible by the 3-phase or single-phase power controller used in each of the cabinets, exclusive of peripherals. Control is effected through a key-operated switch on the control panel of the main cabinet (refer to Figures 3-1, 3-2 and 3-3) and the DEC power control bus that interconnects all power controllers and enables normal power-up and power-down routines as well as emergency shutdown in response to such sensed conditions as overtemperature and insufficient air flow within the main cabinet.

The power controller in each cabinet receives its primary ac power from a separate customer-provided receptacle. In the VAX-11/780 main cabinet, the 3-phase controller distributes 120 Vac or 240 Vac single-phase power to the dc power supplies, to three blowers, an 11/03 microcomputer, and an RX01 floppy disk. The H7100 dc power supplies (up to five, depending on the system configuration) provide the regulated –5.1, –5.2, and +12 Vdc required by the system.

The 3-phase controller for the VAX-11/780 main cabinets and SBI (synchronous backplane interconnect) cabinets shipped prior to June 1978 is the DIGITAL 866D (120/208 Vac) or 866E (240/416 Vac). Shipments subsequent to that date use an improved version of the 866; i.e., the 869D or 869E.

Unibus expansion cabinets shipped prior to September 1978 use the single phase 861C (120 Vac) or 861B (240 Vac) controller. Shipments subsequent to that date use an improved version of the 861; i.e., the 869C (120 Vac) or 869B (240 Vac).

This manual describes the equipment configuration of each cabinet in a basic VAX-11/780 system and shows its physical and electrical relationships to the power distribution system. For corresponding details on VAX-11/780 peripherals, reference should be made to the appropriate manual or manuals for each.

1.4 MANUAL ORGANIZATION

The principal specifications for the VAX-11/780 main cabinet, the power controllers, H7100 power supply, the power supply (H765) for the BA11-K mounting box, and the battery backup supplies (H7111 and H7112) are given in Chapter 2. Chapter 3 is a system-level technical description covering the system configuration, the ac power distribution, the dc power generation and distribution, power-fail provisions, and cabling. Chapter 4 provides a block diagram-level description of the H7100 dc power supply, including regulator options. Appendix A is a general discussion of grounding considerations extracted from the *Corporate Site Preparation Manual.* Appendix B covers the kitting provisions for corrective maintenance on the H7100 dc power supply.

1.5 ENGINEERING DRAWINGS

Table 1-2 lists reference schematics and wiring interconnection diagrams contained in the field maintenance print set for the power distribution system units used in VAX-11/780 system configurations.

Table 1-2 Reference Schematics and Wiring Interconnection Diagrams

Title	DEC Dwg. No.	No. of Sheets
11780 System Power Diagram	D-IC-11780-0-1	6
11780 System Interconnect Diagram	D-IC-11780-0-2	3
11780 Subsystem Interconnect	D-IC-11780-0-3	5
869D Power Controller	D-CS-869-D-1	1
869E Power Controller	D-CS-869-E-1	1
H7100 Interconnect Diagram	E-IC-H7100-0-3	1
Motherboard STAR (H7100)	D-CS-5412550-0-1	1
H7100 Bias/Control	D-CS-5412554-0-1	3
–5.2 V Regulator Board	D-CS-5412560-0-1	1
+12 V Regulator Board	D-CS-5412556-0-1	1
5 V Regulator Battery	D-CS-5412558-0-1	1
Status Card	D-CS-5412562-0-1	1
Bracket AC Assembly	E-AD-7014122-0-0	1
H7112 Interconnect Diagram	C-IC-H7112-0-3	2
Battery Charger	D-CS-5412675-0-1	1
T.O.D.C. P.S. and Backup	D-CS-5412763-0-1	1

CHAPTER 2
PERFORMANCE SPECIFICATIONS

This chapter summarizes the performance specifications for the major elements of the VAX-11/780 power system.

1. Main cabinet (Table 2-1).
2. Model 869D/E 3-phase power controllers (Table 2-2).
3. Model 869B/C single-phase power controllers (Table 2-4).
4. Model 866D/E 3-phase power controllers (Table 2-3).
5. Model 861B/C single-phase power controllers (Table 2-5).
6. H7100 power supply with H7101, H7102 and H7103 regulator options (Table 2-6).
7. H765 power supply of BA11-K mounting box (Table 2-7).
8. H7111 TODC Battery Power Supply (Table 2-8).
9. H7112 Memory Battery Backup Power Supply (Table 2-9).

Table 2-1 VAX-11/780 Main Cabinet Specifications

PHYSICAL CHARACTERISTICS	
Cabinet Type	Double-Width Highboy
Height	152.4 cm (60 in)
Length	118.8 cm (47 in)
Depth	76.2 cm (30 in)
Weight	595.0 kg (1200 lb)
ELECTRICAL CHARACTERISTICS	
AC Power	
Full Load	120/208 V, 3-phase, 50/60 Hz 6.0 kVA nominal; 7.2 kVA maximum 240/416 V, 3-phase, 50/60 Hz 6.0 kVA nominal; 7.2 kVA maximum
Voltage/Frequency Tolerances	
100–127 Vac (phase to neutral)	47–63 Hz
200–254 Vac (phase to neutral)	47–63 Hz

Table 2-1 VAX-11/780 Main Cabinet Specifications (Cont)

ELECTRICAL CHARACTERISTICS (Cont)	
Current	
Steady State	20 A/phase; 20 A in neutral line
Surge (power turn-on)	150 A/phase
Surge Duration	5 ms at 120/208 Vac
Power Cable	
Length	4.5 m (15 ft)
Plugs/Receptacles	
869D/E Controllers	(Table 2-2)
866D/E Controllers	(Table 2-3)
DC Power	Refer to H7100 Power Supply Specification (Table 2-6)
ENVIRONMENTAL CHARACTERISTICS	
Temperature	
Operating	15° to 32° C (58° to 95° F)
Non-Operating	–40° to 60° C (–40° to 151° F)
Relative Humidity	
Operating	20 to 80% with maximum wet bulb 25° C (77° F) and minimum dew point 2° C (36° F)
Air Flow at Inlet	705 l/s (1500 ft^3/min)
Altitude	
Operating	2400 m (8000 ft), maximum
Non-Operating	9100 m (30,000 ft), maximum
Heat Dissipation	5500 kg cal/hr (22000 Btu/hr) 6450 W

Table 2-2 Model 869D/E Power Controller Specifications

AC INPUT

Voltage	Phase	Phase-to-Neutral	Nominal
869D	3	90–132 Vac	120 Vac
869E	3	180–264 Vac	240 Vac

Frequency

869D	47–63 Hz
869E	47–63 Hz

Current Capability

869D	24 A/phase at 120 Vac
869E	12 A/phase at 240 Vac

Input Power Capability	Full Load
869D	8.640 kVA
869E	8.640 kVA

Inrush Current Capability

869D	450 A peak for 1/2 cycle at 60 Hz
869E	225 A peak for 1/2 cycle at 50 Hz

Input Overvoltage Transient
(power controller only)

869D	150 V for 1 s, phase to neutral
869E	300 V for 1 s, phase to neutral

Leakage Current Contribution
(power controller only)

869D	1.5 mA at 250 V, 50 Hz
869E	1.5 mA at 250 V, 50 Hz

Circuit Breaker Rating

869D	30 A/pole (4 poles) with inrush protection
869E	15 A/pole (4 poles) with inrush protection

Primary Power Connections	3 phases, 120° displaced
869D	120/208 Vac wye, 4-wire plus safety ground
869E	240/416 Vac wye, 4-wire plus safety ground

Table 2-2 Model 869D/E Power Controller Specifications (Cont)

AC INPUT (Cont)	
AC Connection	
869D	Power Cord – 7015253 Receptacle – 12-12315; Hubbell 2810; NEMA L21-3OR
869E	Power Cord – 7015254 Receptacle – 12-14378-02*; Hubbell 52OR7; NEMA N/A Without power cord – Five 10-32 studs
CONTROL PARAMETERS	
Thermoswitch (exposed to outside ambient air)	
Opens contactor at	71° C (160° F)
Automatically resets at	49° C (120° F)
Input-Signal Current Levels	
High	500 μA maximum
Low	20 mA maximum
Input-Signal Voltage Levels	
High	3 to 35 V
Low	0 to 1.8 V
Connectors	
Female (3)	DEC 12-09350-03 with DEC 12-09379 pins
Male (3)	DEC 12-09351-03 with DEC 12-09378 pins
Power Control Bus	Meets DEC Standard 123: Pin 1 – Power Request Pin 2 – Emergency Shutdown Pin 3 – Ground
Air Flow Sensors	Texas Instrument 2SE (DEC 12-14447)
AC OUTPUT	
Duplex Receptacles	
869D	9 (120 Vac, 20 A; J11–J19)
869E	9 (240 Vac, 15 A; J11–J19)

*DEC-supplied with the 869E Controller.

Table 2-2 Model 869D/E Power Controller Specifications (Cont)

AC OUTPUT (Cont)	
Circuit Breakers	
869D	20 A per duplex outlet
869E	None
Maximum Output Current/Phase	
869D	Phase 1 (J11, J12, J13) – 24 A Phase 2 (J14, J15, J16) – 24 A Phase 3 (J17, J18, J19) – 24 A
869E	Phase 1 (J11, J12, J13) – 12 A Phase 2 (J14, J15, J16) – 12 A Phase 3 (J17, J18, J19) – 12 A
Loads	**CAUTION** **No loads external to the cabinet are to be plugged into the controller.**
MECHANICAL AND ENVIRONMENTAL	
Size	
Height	12.7 cm (5 in)
Width	48.26 cm (19 in)
Depth	25.4 cm (10 in)
Weight	13.5 kg (30 lb)
Cooling	Convection
Mounting	48.26 cm (19 in) rack
Temperature	
Operating	5° to 50° C (41° to 122° F)
Non-operating	–40° to +66° C (–40° to 151° F)
Humidity	10 to 95% with maximum wet bulb 32° C (90° F) and minimum dew point 2° C (36° F)

Table 2-3 Model 869C/B Power Controller Specifications

AC INPUT			
Voltage	**Phase**	**Range**	**Nominal**
869C	1	90–132 Vac	120 Vac
869B	1	180–264 Vac	240 Vac
Frequency			
869C		47–63 Hz	
869B		47 - 63 Hz	
Current Capability			
869C		24 A/phase at 120 Vac	
869B		16 A/phase at 240 Vac	
Input Power Capability			
869C		2.88 kVA (full load)	
869B		2.88 kVA (full load)	
Inrush Current Capability			
869C		540 A peak for 1/2 cycle at 50 Hz	
869B		270 A peak for 1/2 cycle at 50 Hz	
Input Overvoltage Transient (power controller only)			
869C		150 V for 1 s	
869B		300 V for 1 s	
Leakage Current Contribution (power controller only)			
869C		1.5 mA at 250 V, 50 Hz	
869B		1.5 mA at 250 V, 50 Hz	
Input Circuit Breaker			
869C		30-20-20 A with inrush protection	
869B		20-15-15 A with inrush protection	
Primary Power Connection			
869C		120 Vac, 2-wire with ground	
869B		240 Vac, 2-wire with ground	

Table 2-3 Model 869C/B Power Controller Specifications (Cont)

AC INPUT (Cont)

AC Connection

869C	DEC	NEMA	Hubbell
Power Cord and Plug Assy	7015253		
Plug	12-11193	L5-30P	2611
Receptacle	12-11194	L5-30R	2610
869B			
Power Cord and Plug Assy	7015474		
Plug	12-14379-03	N/A	320P6
Receptacle	12-14378-03	N/A	320R6

CONTROL PARAMETERS

Thermoswitch (exposed to outside ambient air)

Opens contactor at	71° C (160° F)
Automatically resets at	49° C (120° F)
Controls	Total Shutdown

Input-Signal Current Levels

High	500 μA maximum
Low	10 mA maximum

Input-Signal Voltage Levels

High	3 to 35 V
Low	0 to 1.8 V

Power Control Bus	Meets DEC Std 123 Pin 1 – Power Request Pin 2 – Emergency Shutdown Pin 3 – Ground

Connectors

Female (3)	DEC 12-09350-03 with DEC 12-09379 pins
Male (3)	DEC 12-09351-03 with DEC 12-09378 pins
Air Flow Sensors	Texas Instrument 2SE (DEC 12-14447)

AC OUTPUT

Duplex Receptacles

869C	5 (120 Vac, 20 A; J1–J5)
869B	5 (240 Vac, 15 A; J1–J5)

Table 2-3 Model 869C/B Power Controller Specifications (Cont)

AC OUTPUT (Cont)	
Circuit Breakers	
869C	
Branch 1 (J2, J4, J5)	16 A maximum per duplex outlet
Branch 2 (J1, J3)	16 A maximum per duplex outlet (Sum of branches 1 and 2 not to exceed 24 A)
869B	
Branch 1 (J2, J4, J5)	12 A maximum per duplex outlet
Branch 2 (J1, J3)	12 A maximum per duplex outlet (Sum of branches 1 and 2 not to exceed 16 A)
Maximum Output Current	
869C	16 A per duplex outlet
869B	12 A per duplex outlet
MECHANICAL AND ENVIRONMENTAL	
Size	
Height	8.18 cm (3.22 in)
Width	48.26 cm (19 in)
Depth	21.20 cm (8.35 in)
Weight	6.75 kg (15 lb)
Cooling	Convection
Mounting	48.26 cm (19 in) rack
Temperature	
Operating	5° to 50° C (41° to 122° F)
Non-Operating	–40° to 66° C (–40° to 151° F)
Humidity	10 to 95% with maximum wet bulb 32° C (90° F) and minimum dew point 2° C (36° F)

Table 2-4 Model 866D/E Power Controller Specifications

INPUT	
Voltage	
866D	90–132 Vac, 3-phase wye
866E	180–264 Vac, 3-phase wye

Table 2-4 Model 866D/E Power Controller Specifications (Cont)

INPUT (Cont)	
Frequency	
866D/E	47 to 63 Hz
Current	
866D	24 A maximum at 120 V
866E	12 A maximum at 240 V
Input Power at No Load	
866D/E	10 W maximum
Input VA at Full Load	
866D/E	8640
Inrush Current	
866D	450 A peak for 1/2 cycle at 50 Hz
866E	225 A peak for 1/2 cycle at 50 Hz
Input Overvoltage Transient (power controller alone)	
866D	150 V for 1 s, phase to neutral
866E	300 V for 1 s, phase to neutral
Leakage Current (power controller alone)	
866D/E	1.5 mA at 250 V, 50 Hz
Circuit Breaker	
866D	30-30-30-30 A, 4 pole
866E	15-15-15-15 A, 4 pole
Power Cord and Plug	
866D	5 wire #10; NEMA L21-30P; Hubbell 2811
866E	5 wire #14; NEMA L22-20P; Hubbell 2521
CONTROL PARAMETERS	
Thermoswitch (exposed to outside ambient air)	
Opens contactor at	71° C (160° F)
Auto resets at	49° C (120° F)

Table 2-4 Model 866D/E Power Controller Specifications (Cont)

CONTROL PARAMETERS (Cont)	
Input Signal Current Levels	
High	500 μA maximum
Low	20 mA maximum
Input Signal Voltage Levels	
High	+35 V minimum
Low	+1.8 V maximum
Connectors	
Female (3)	DEC 12-09350-03 with DEC 12-09379 pins
Male (3)	DEC 12-09351-03 with DEC 12-09378 pins
AC OUTPUT	
Duplex Receptacles	
866D	5 switched; 2 unswitched; 125 V phase to neutral (20 A, NEMA 5-20R)
866E	5 switched; 2 unswitched; 250 V phase to neutral (15 A, NEMA 6-15R)
Current	
Per Duplex Receptacle	
866D	16 A peak at 120 Vac, phase to neutral
866E	12 A peak at 240 Vac, phase to neutral
Per Phase	
866D	24 A at 120 Vac, phase to neutral
866E	16 A at 240 Vac, phase to neutral
Loads	CAUTION **No loads external to the cabinet are to be plugged into the controller.**
MECHANICAL AND ENVIRONMENTAL	
Dimensions	
Height	12.7 cm (5 in)
Width	48.6 cm (19.1 in)
Depth	20.3 cm (8 in)

Table 2-4 Model 866D/E Power Controller Specifications (Cont)

MECHANICAL AND ENVIRONMENTAL (Cont)	
Weight	12.15 kg (27 lb)
Cooling	Convection
Mounting	48.26 cm (19 in) rack
Temperature	
Operating	5° to 50° C (41° to 122° F)
Non-Operating	–40° to 66° C (–40° to 151° F)
Humidity	10 to 95% with maximum wet bulb 32° C (90° F) and minimum dew point 2° C (36° F)

Table 2-5 Model 861B/C Power Controller Specifications

INPUT	
Voltage	
861B	180–264 Vac, single phase
861C	90–132 Vac, single phase
Frequency	
861B/C	47–63 Hz
Current	
861B	16 A at 240 Vac
861C	24 A at 120 Vac
Input Power at No Load	
861B/C	10 W maximum
Input VA at Full Load	
861B	3840
861C	2880
Inrush Current	
861B	225 A peak for 1/2 cycle at 50 Hz
861C	340 A peak for 1/2 cycle at 50 Hz

Table 2-5 Model 861B/C Power Controller Specifications (Cont)

INPUT (Cont)	
Input Overvoltage Transient (power controller alone)	
861B	300 V for 1 s, phase to neutral
861C	150 V for 1 s, phase to neutral
Leakage Current (power controller alone)	
861B/C	1.5 mA at 250 V, 50 Hz
Circuit Breaker	
861B	20-20-20 A, 3-pole
861C	20-20-30 A, 3-pole
Power Cord and Plug	
861B	3 wire #14; NEMA L6-20P; Hubbell 2321
861C	3 wire #12; NEMA L5-30P; Hubbell 2611
CONTROL PARAMETERS	
Thermoswitch (exposed to outside ambient air)	
Opens contactor at	71° C (160° F)
Auto resets at	49° C (120° F)
Input Signal Current Levels	
High	500 μA maximum
Low	20 mA maximum
Input Signal Voltage Levels	
High	+35 V minimum
Low	+1.8 V maximum
Connectors	
Female (3)	DEC 12-09350-03 with DEC 12-09379 pins
Male (3)	DEC 12-09351-03 with DEC 12-09378 pins
AC OUTPUT	
Duplex Receptacles	
861C	4 switched; 2 unswitched; 125 Vac phase to neutral (20 A NEMA 5-20R)
861B	4 switched; 2 unswitched; 250 Vac phase to neutral (15 A NEMA 6-15R)

Table 2-5 Model 861B/C Power Controller Specifications (Cont)

AC OUTPUT (Cont)	
Current	
Per Duplex Receptacle	
861C	16 A peak at 120 Vac phase to neutral
861B	12 A peak at 240 Vac phase to neutral
Per Phase, Maximum	
861C	24 A at 120 Vac phase to neutral
861B	16 A at 240 Vac phase to neutral
Loads	

CAUTION
No loads external to the cabinet are to be plugged into the controller.

MECHANICAL AND ENVIRONMENTAL	
Dimensions	
Height	12.7 cm (5 in)
Width	48.6 cm (19.1 in)
Depth	20.3 cm (8 in)
Weight	4.5 kg (10 lb)
Cooling	Convection
Mounting	48.26 cm (19 in) rack
Temperature	
Operating	5° to 50° C (41° to 122° F)
Non-Operating	–40° to 66° C (–40° to 151° F)
Humidity	10 to 95% with maximum wet bulb 32° C (90° F) and minimum dew point 2° C (36° F)

Table 2-6 H7100 DC Power Supply Specifications

MECHANICAL AND ENVIRONMENTAL	
Dimensions	
Width	17.8 cm (7 in)
Height	27.9 cm (11 in)
Depth	40.6 cm (16 in)
Weight	15.9 kg (35 lb)

Table 2-6 H7100 DC Power Supply Specifications (Cont)

MECHANICAL AND ENVIRONMENTAL (Cont)	
Cooling	External forced air at 2.22 m/s (400 linear ft/min)
Temperature	
Operating	5° C (40° F) to 50° C (122° F)
Storage	–40° C (40° F) to 65° C (149° F)
Altitude	
Operating	3000 m (10,000 ft) maximum
Non-Operating	9100 m (30,000 ft) maximum
ELECTRICAL	
Input	
Voltage (single phase, 2-wire)	90–128 V, rms 180–256 V, rms
Frequency	47–63 Hz
Current, maximum	
At 120 Vac, nominal	10.0 A, rms
At 240 Vac, nominal	5.0 A, rms
Inrush Current	80 A peak maximum for 1/2 cycle at 128 V rms or 256 V rms
Power, apparent	1200 VA
Power factor	>60% at full load (90–128 V rms)
Input protection	2-pole circuit breaker, 20 A/phase
Output	
Power	500 W
Voltage/current	+5.1 V at 10.0 to 100 A (H7100)
	+12 V at 1.0 to 10 A (H7102 regulator option)
	-5.2 V at 3.0 to 30 A (H7101 regulator option)
	+5.0 V at 2.0 to 20 A (H7103 regulator option)
	-5.0 V at 0 to 0.2 A (H7103 regulator option)
Regulation (all dc outputs)	±5%

Table 2-6 H7100 DC Power Supply Specifications (Cont)

ELECTRICAL (Cont)	
Status Indicators	
Power normal	Green LED
Overcurrent	Red LED
Overvoltage	Red LED
Power inverter failure	Red LED
Plug-In regulator failure	Red LED
Overtemperature	Reflective Indicator (yellow)
Battery Backup (Optional H7112 Unit)	
Duration	10 minutes, minimum
Voltage/current	+5 V at 18.5 A (H7103)
	+12 V at 4.6 A (H7102)
	-5 V at 0.2 A (H7103)

Table 2-7 BA11-K Mounting Box – DC Power Supply Specifications

1. 120 Vac Input Power – BA11-KE

Parameter	**Specifications**
Input power	90–132 Vac, 120 Vac nominal 47–63 Hz, single phase
Inrush current	175 A peak for 10 ms maximum at 120 V line voltage
Input power	1200 W maximum at 120 V nominal line voltage
Input current	12 A maximum at 120 Vac
Circuit breaker rating	20 A at 120 Vac
Power factor	The ratio of input power to apparent power must be greater than 0.85
Noise Transients	Single transient 300 V at 0.2 W-s maximum
	Single transient, survival: 1000 V at 2.5 W-s maximum
	Average transient power survival: 0.5 W maximum
CW Noise	10 kHz–3 MHz: 3 V rms 3 MHz–500 MHz: 1 V rms 500 MHz–1000 MHz: 0.5 V rms
RF field susceptibility	10 kHz–1000 MHz: 1 V/m

Table 2-7 BA11-K Mounting Box – DC Power Supply Specifications (Cont)

Parameter	Specifications
Power fail	H765 power system is capable of withstanding power interruptions of any magnitude and duration without damage. Storage time of power supply at low line and full load shall be 20 ms minimum. Storage time is measured from the time the power outage occurs until the time the 5411086 regulator or a regulator unit (1 through 4) voltage drops below its specified regulation limits.

2. 240 Vac Input Power - BA11-KE

Parameter	Specifications
Input power	180–264 Vac, 240 Vac nominal 47–63 Hz, single phase
Inrush current	80 A peak for 10 ms maximum at 240 Vac line voltage
Input power	1200 W maximum at 240 Vac nominal line voltage
Input current	6 A maximum at 240 Vac
Circuit breaker rating	10 A at 240 Vac
Power factor	The ratio of input power to apparent power shall be greater than 0.85.
Noise	
Transients	Single transient, without loss of data: 300 V at 0.2 W-s
	Single transient, survival: 1000 V at 2.5 W-s maximum
CW Noise	10 kHz–3 MHz: 3 V rms 3 MHz–50 MHz: 1 V rms 500 MHz–1000 MHz: 0.5 V rms
RF field susceptibility	10 kHz–1000 MHz: 1 V/m
Power fail	H765 power system is capable of withstanding power interruptions of any magnitude and duration without damage. Storage time of power supply at low line and full load shall be 20 ms minimum. Storage time is measured from the time the 5411086 regulator or a regulator unit (1 through 4) voltage drops below its specified regulation limits.

Table 2-7 BA11-K Mounting Box – DC Power Supply Specifications (Cont)

3. Power-Up and Power-Down Characteristics

Parameter	Specification
Mounting Box Power Down	5 ms minimum from ACLO L asserted to DCLO L asserted
Mounting Box Power Up	1 ms minimum from +15 V to DCLO L negated
	2 ms nominal from DCLO L negated to ACLO L negated
Static Performance at full load*	
Mounting Box Power Down	ACLO L drops to LOW: 83–88 Vac DCLO L drops to LOW: 73–78 Vac
Mounting Box Power Up	DCLO L goes to HIGH: 75–80 Vac ACLO L goes to HIGH: 85–90 Vac

4. H765 Regulator Unit Assembly Configurations

Item	Power System	AC Input	Regulator Unit	Quantity
1	H765-A	115	H744	2
			H745	1
			H754	1
2	H765-B	230	H744	2
			H745	1
			H754	1
3	H765-C	115	H744	2
			H745	1
4	H765-D	230	H744	2
			H745	1
5	70-13323-02	115	H7441	2
			H745	1
			H754 (MOS/core)	1
			H765P	1
6	70-13323-04	230	H7441	2
			H745	1
			H785 (BBU)*	1
			H765R	1
7	70-13323-00	115	H7441	2
			H745	1
			H765P	1

*Response to changing ac input (less than 10 V/s).

Table 2-7 BA11-K Mounting Box – DC Power Supply Specifications (Cont)

Item	Power System	AC Input	Regulator Unit	Quantity
8	70-13323-03	230	H7441 H745 H765P	2 1 1
9	70-13323-01	115	H7441 H745 H765P	2 1
10	70-13323-05	230	H7441 H745 H754 (MOS/core) H765R	2 1 1

5. **Mounting Box Physical and Environmental Characteristics**

Item	Description
Chassis size (with H765 power system and pop panel)	26.52 cm (10.44 in) high 43.48 cm (17.12 in) wide 67.39 cm (26.53 in) deep
Chassis size (with H765 power system without console panel and bezel)	26.52 cm (10.44 in) high 43.48 cm (17.12 in) wide 63.50 cm (25 in) deep
Chassis size (without H765 power system, console panel, and bezel)	26.52 cm (10.44 in) high 43.48 cm (17.12 in) wide 43.82 cm (17.25 in) deep
Expander box chassis weight (with regulator units and without system units)	39.47 kg (87 lb)
H765 power system size	26.37 cm (10.38 in) high 43.48 cm (17.12 in) wide 19.69 cm (7.75 in) deep
Slide extension (three-section slide)	68.58 cm (27 in) maximum
Slide weight capacity (box fully extended)	68.04 kg (150 lb)
3-stop slide	Positions: horizontal, 45° F and 90° F (front panel facing up)
Fan air movement direction	Horizontally toward rear of chassis

Table 2-7 BA11-K Mounting Box – DC Power Supply Specifications (Cont)

Item	Description
Module slots	22 maximum (2 double system units and 1 single system unit), using DIGITAL standard configuration backplanes
Operating temperature range at inlet to box	5° C–50° C (41° F–122° F)
Operating humidity	10 to 95% (no condensation)
Cooling efficiency for both fans at 90 Vac, 50 Hz	Temperature rise no greater than 10° C (18° F) inlet air temperature to exhaust air.

Table 2-8 H7111 TODC Battery Power Supply Specifications

AC INPUT	
Current	0.1 A, maximum rms
Voltage	
90–128 Vac, rms	H7111A
180–256 Vac, rms	H7111B
Frequency	47 to 63 Hz
Protection	1/8 A slow-blow fuse
DC OUTPUT	
Voltage	+5 Vdc ±5%
Current	0 to 25 mA
BAT DCLO	
High state	4.0 to 4.5 Vdc
Low state	Less than 0.4 Vdc at sink 4 mA maximum
Connector	6-pin universal Mate-N-Lok
MECHANICAL AND ENVIRONMENTAL	
Dimensions	
Height	8.9 cm (3.5 in)
Width	48.26 cm (19 in)
Depth	10.20 cm (4.0 in)

Table 2-8 H7111 TODC Battery Power Supply Specifications (Cont)

MECHANICAL AND ENVIRONMENTAL (Cont)	
Weight	2.25 kg (5 lb)
Cooling	Convection
Mounting	48.26 cm (19 in) rack
Temperature	
Operating	5° to 50° C (41° to 122° F)
Non-Operating	–40° to 66° C (–40° to 151° F)
Humidity	10% to 95% with maximum wet bulb 32° C (90° F) and minimum dew point 2° C (36° F)
Altitude	
Operating	3000 m (10,000 ft)
Non-Operating	9000 m (30,000 ft)
Battery Shelf Life	
At 70° C (158° F)	40 days, maximum
At 0° C (32° F)	6000 days, maximum
Battery	
Type	Sealed lead-acid (DEC P/N 1212499-00)
Voltage range	10–16 Vdc
Overcurrent protection	2 A fuse
Capacity	5 Ah
Charge time	Less than 24 hr (90% charge)
Operating time	100 hr, minimum

Table 2-9 H7112 Memory Battery Backup Power Supply Specifications

AC INPUT

Voltage Range	Voltage Nominal	Frequency	Current
90–128 Vac	120 Vac	60 Hz ±1 Hz	1.0 A, maximum
180–256 Vac	240 Vac	60 Hz ±1 Hz	0.5 A, maximum
90–128 Vac	120 Vac	50 Hz ±1 Hz	1.0 A, maximum
180–256 Vac	240 Vac	50 Hz ±1 Hz	0.5 A, maximum

Table 2-9 H7112 Memory Battery Backup Power Supply Specifications (Cont)

AC INPUT (Cont)	
Charge Time (90% charge)	16 hr, maximum
Input protection	
120 Vac	1.0 A slow-blow fuse
240 Vac	0.5 A slow-blow fuse
DC OUTPUT	
Voltage	27–45 Vdc
Power	250 W (constant power load)
Battery Holdup Time	10 minutes, minimum
INPUT SIGNALS	
Regulator input voltage	30 Vdc
AC OK voltage	–12 ±3 Vdc
Closure	J7-3 to J7-6
BATTERIES (3 in series)	
Type	Sealed lead-acid (DEC P/N 1212499-00)
Voltage range	30–48 Vdc
Overcurrent protection	15 A fuse
Power required	280 W
ENVIRONMENTAL AND PHYSICAL	
Dimensions	
Height	13.2 cm (5.2 in)
Width	48.26 cm (19.0 in)
Depth	15.64 cm (6.16 in)
Weight	11.25 kg (25 lb), approximately
Cooling	Convection
Mounting	48.26 cm (19 in) rack
Temperature	
Operating	5° to 50° C (41° to 122° F)
Non-Operating	–40° to 66° F (–40° to 151° F)

Table 2-9 H7112 Memory Battery Backup Power Supply Specifications (Cont)

ENVIRONMENTAL AND PHYSICAL (Cont)	
Humidity	10 to 95% with maximum wet bulb 32° C (90° F) and minimum dew point 2° C (36° F)
Altitude	
Operating	3000 m (10,000 ft)
Non-Operating	9100 m (30,000 ft)
Battery Shelf Life*	
At 70° C (158° F)	40 days, maximum
At 0° C (32° F)	6000 days, maximum
Connectors and Cables	Two 3-pin (J10, J11) AC input cable BATTERY OUT interface cable Two binding posts for external battery

*Shelf life is linear between these extremes.

CHAPTER 3
POWER SYSTEM DESCRIPTION

This chapter discusses the VAX-11/780 Power System under the following basic headings:

1. Physical configuration (includes a brief description and illustrations showing relationships between power system and other system elements)

2. AC power distribution

3. DC power generation and distribution

4. Power failure provisions (e.g., power-fail sequencing, battery backup power supplies, and power supply status displays)

5. Cabling.

In overview, power distribution within the system is not complicated. Each cabinet power controller receives its 3-phase or single-phase primary power directly from an individual customer-supplied receptacle. The controller then distributes this power throughout its cabinet, providing 120 Vac or 240 Vac to the individual loads (e.g., dc power supplies, fans, microcomputer, floppy disk, air flow interface, etc.).

In the main cabinet (refer to Paragraph 3.1) the microcomputer and floppy disk have their own internal power supplies. The dc power supplies provide +5.1, –5.2 and +12 regulated outputs for the numerous modules in the CPU, UBA, memory, MBA, and FPA. The air flow interface (used with the 866 controllers only) provides +15 Vdc for the air flow sensors. In the 869 controllers this voltage is provided by circuits in the unit.

All cabinets in the VAX-11/780 (main cabinet, expander cabinet(s), and tape drive cabinets) are powered up and down via the DEC power control bus that interconnects them. However, system standalone peripherals operate autonomously. Although an emergency shutdown signal on the control bus shuts down those devices operating off "switched" controller outlets, the units (e.g., memory power supply, memory power supply fan, and air flow interface) on "unswitched" receptacles will continue to operate until the controller's main circuit breaker can be manually set to OFF. This restriction does not apply to the more advanced 869 series controllers, whose main circuit breaker incorporates a trip coil permitting total shutdown of both switched and unswitched power. Details of 869 operation are discussed in the following sections.

Centralized control of power distribution initiates at a key-operated switch at the right end of the main cabinet control panel (refer to Figure 3-1).

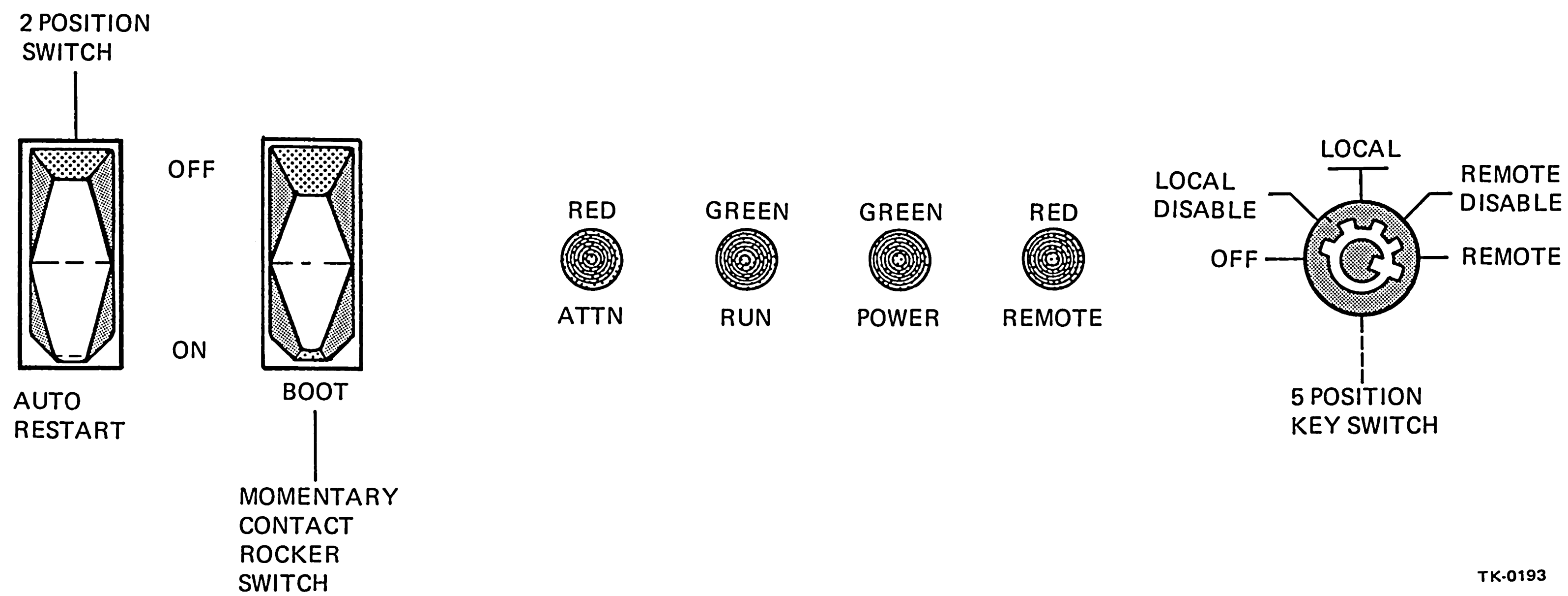


Figure 3-1 VAX-11/780 Control Panel on Main Cabinet

3.1 PHYSICAL CONFIGURATION

The basic VAX 11/780 computer system comprises (refer to Figure 3-2):

1. A 1.5 m (5 ft) tall, 1.2 m (4 ft) wide (double-width) highboy central processor unit (CPU) cabinet

2. A 1.5 m (5 ft) tall, 0.6 m (2.2 ft) wide (single-width) highboy Unibus expansion cabinet

3. Storage devices (e.g., tapes, disks, etc.)

4. LA36 DECwriter II console terminal.

3.1.1 Main Cabinet

The main cabinet houses the following basic equipment:

1. Central processor unit (KA780)

2. 256K-byte MOS memory (MS780)

3. Unibus adapter (DW780)

4. Two power supplies for the CPU

5. One power supply for the memory

6. Three cooling blowers

7. Time-of-day clock battery power supply

8. 11/03 microcomputer

9. RX01 floppy disk subsystem

10. 869 or 866 3-phase power controller (located behind the RX01 in Figure 3-2).

In addition, the main cabinet provides space for the following optional equipment:

1. FP780-AA(AB) high-performance floating-point accelerator.

2. Writable Control Store (WCS) of 1K locations (KU780)

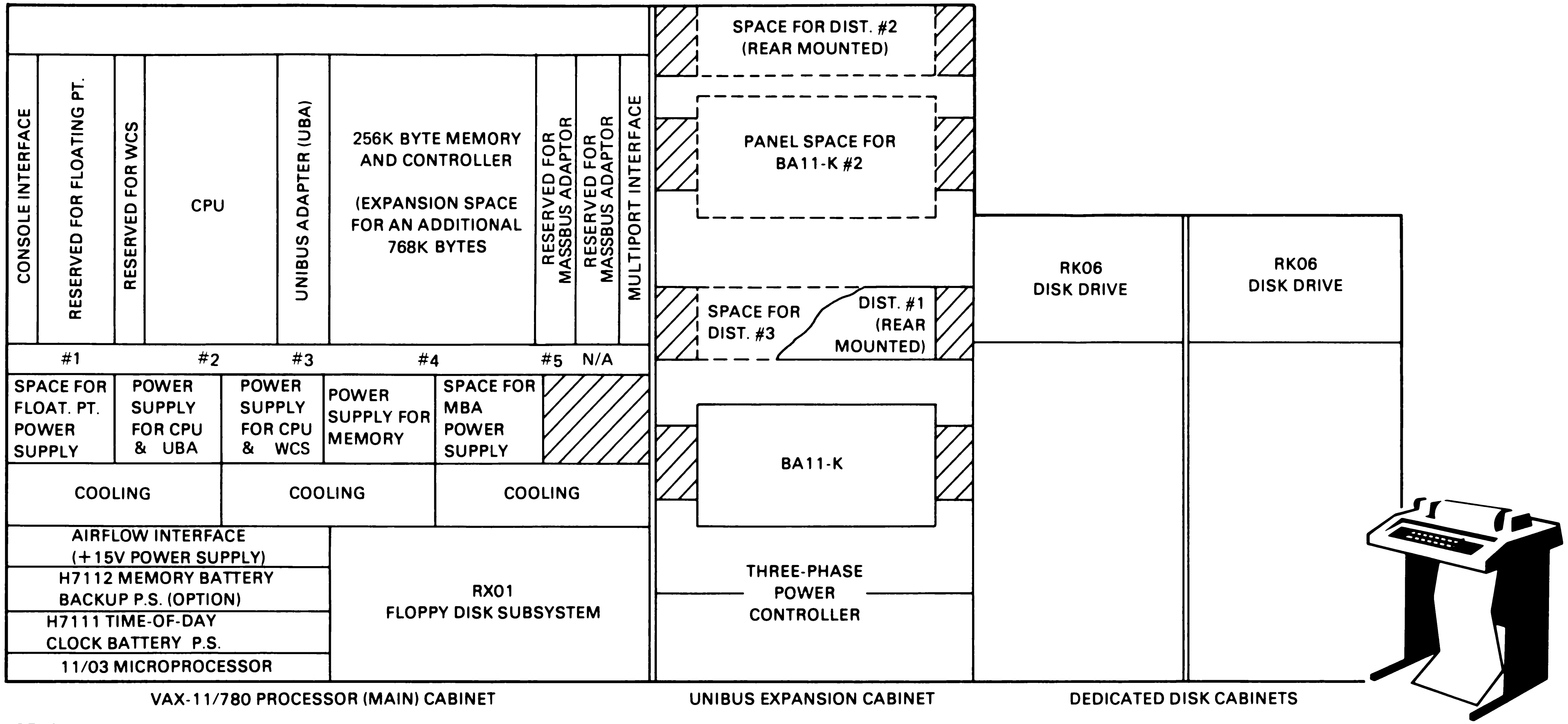
3. Up to 4 megabytes of ECC MOS memory

4. Two Massbus adapters (RH780)

5. Power supply for floating-point option

6. Power supply for Massbus option

7. Memory battery backup power supply option.



NOTES:
IN THE MAIN CABINET, THE THREE-PHASE POWER CONTROLLER (869 or 866) IS RACK MOUNTED BEHIND THE RX01 FLOPPY DISK.

ANY CABINET USING AN 866 CONTROLLER ALSO HAS AIRFLOW INTERFACE UNIT 7015036; CABINETS USING THE 869 CONTROLLER DO NOT REQUIRE THIS UNIT.

POWER SUPPLY #Z ALSO SUPPLIES -5.2v TO ALL MAIN CABINET MODULES (SEE FIGURE 3-26)

Figure 3-2 VAX-11/780 Basic Configuration

3.1.2 Unibus Expansion Cabinet

The Unibus expansion cabinet is an integral component of all VAX-11/780 systems. It houses a maximum of two BA11-K mounting boxes, (each with integral power supply) and provides space to accommodate three distribution panels for handling a total of up to 48 asynchronous multiplex lines.

At installation, the expansion cabinet is physically mated to the main cabinet or, the model H9602 expansion cabinet (if used).

3.1.3 VAX-11/780 Expansion Cabinet (H9602-HA/HB)

The VAX-11/780 expansion (SBI) cabinet (refer to Figure 3-3) is a single-width highboy having the same dimensions as the Unibus expansion cabinet. When used, it is physically mated with the main cabinet at its left end and the Unibus expansion cabinet at its right end. The H9602-HA/HB provides mounting space for:

1. Up to one million bytes of expansion memory with memory control
2. Two Massbus adapters (RH780)
3. One memory battery backup option (H7112-A/B)
4. Power supply for the memory
5. Power supply for the MBAs.

To expand the VAX-11/780 system beyond the limits of the Unibus expansion cabinet shown in Figure 3-2, an add-on Unibus expansion cabinet (H9602-DF/DH) is available. Figure 3-3 shows the space allocations of the Unibus add-on expansion cabinet and the VAX-11/780 H9602-HA/HB expansion cabinet as seen from the front. Figure 3-4 is a top view of the BA11-K extension mounting box used with the Unibus expansion cabinet and the add-on Unibus expansion cabinet. Shown in this figure are the DD11-DK peripheral mounting panel, DZ11-A asynchronous multiplexer for the video terminals (e.g., VT52s) used in some configurations, and the RK611 controller (five boards and backplane) for the RK06 disk drives. Figures 3-5 and 3-6 show the configuration of the mounting box and its power supply, respectively.

The RK611 and DD11-DK each occupy 2 SUs (system units) of space and provide a total of 8 hex slots and 3 quad slots of additional mounting space.

Figures 3-7 and 3-8 show front and rear exterior views of the 11/780-C main cabinet, respectively. Accompanying sheets for each figure give cabling data.

For details of the BA11-K extension mounting box, refer to the *BA11-K Mounting Box Manual* (DEC-11-HBKEF-A-D) included in the documentation package for VAX-11/780 systems.

3.2 AC POWER DISTRIBUTION

In VAX-11/780 systems delivered after June 1978, the 866 3-phase controllers are replaced by more versatile equivalents of the new 869 series. To simplify the discussion on ac power distribution, it should be pointed out that all of these DEC standard power controllers (refer to Tables 3-1 and 3-2) have similarities. Figure 3-9 shows their common basic concept.

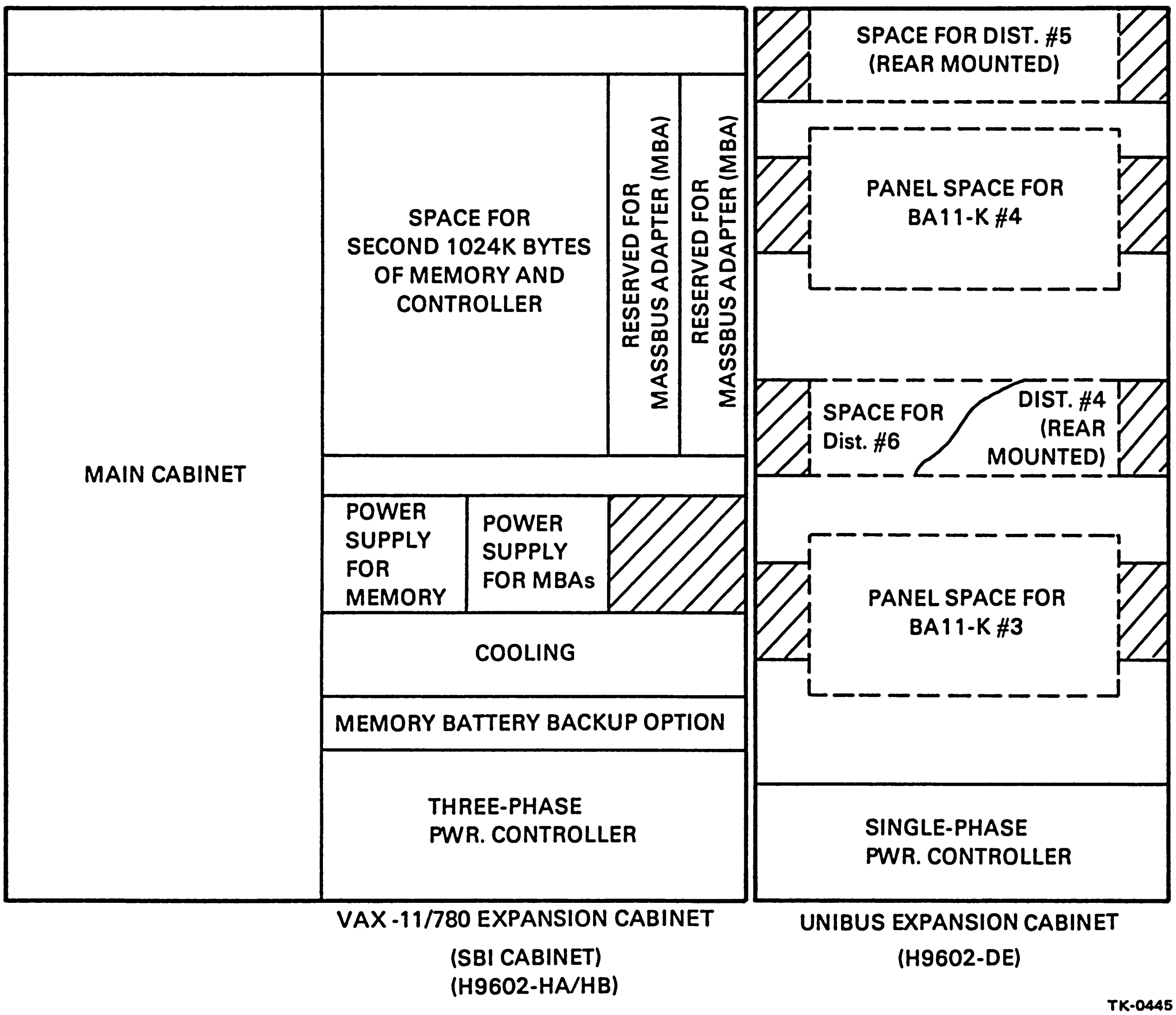


Figure 3-3 Equipment Space Allocation in Add-On Cabinets (Front View)

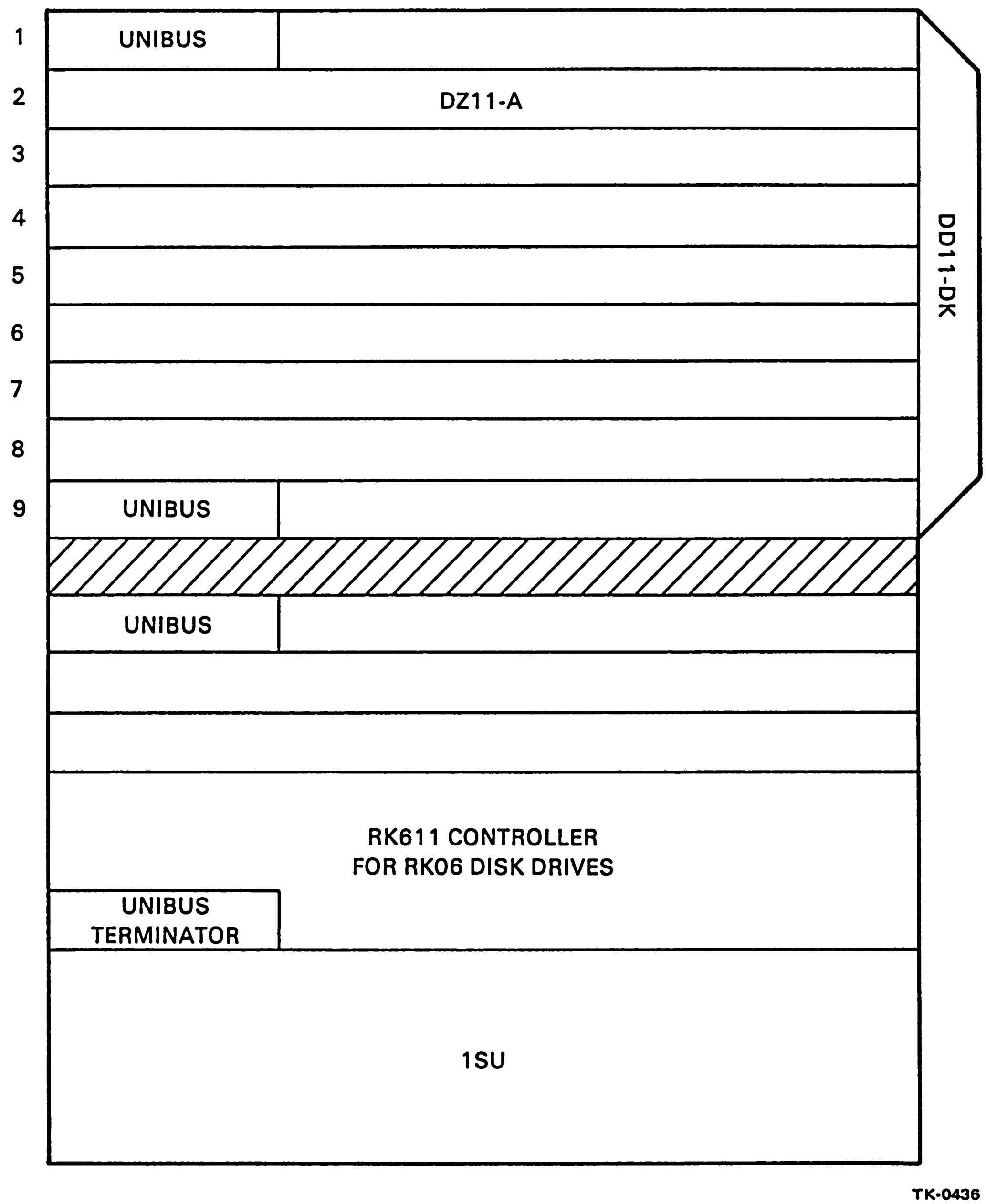


Figure 3-4 Space Allocation for DZ11-A Multiplexer and RK611 Controller in BA11-K Mounting Box

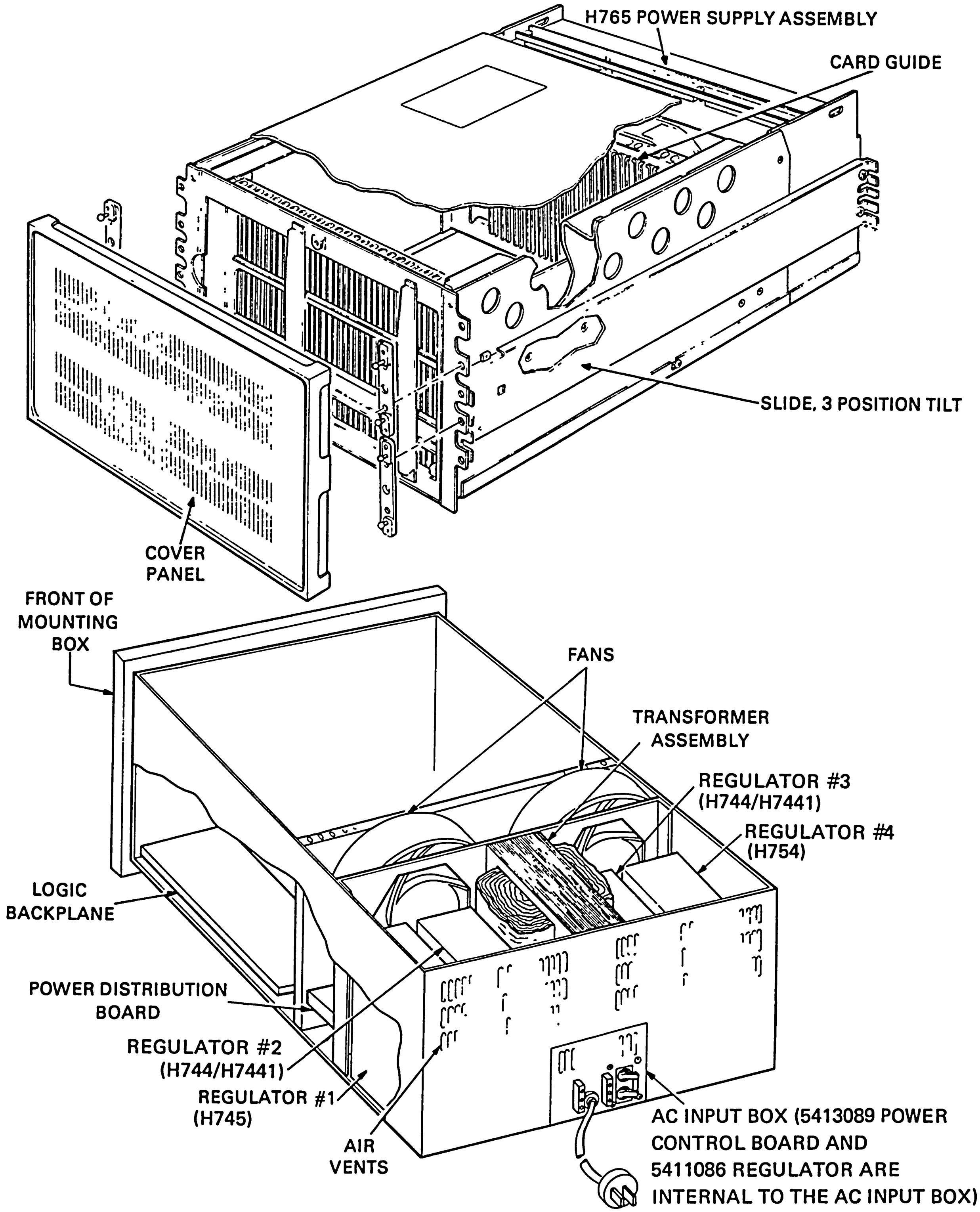


Figure 3-5 BA11-K 10.5 Inch Mounting Box

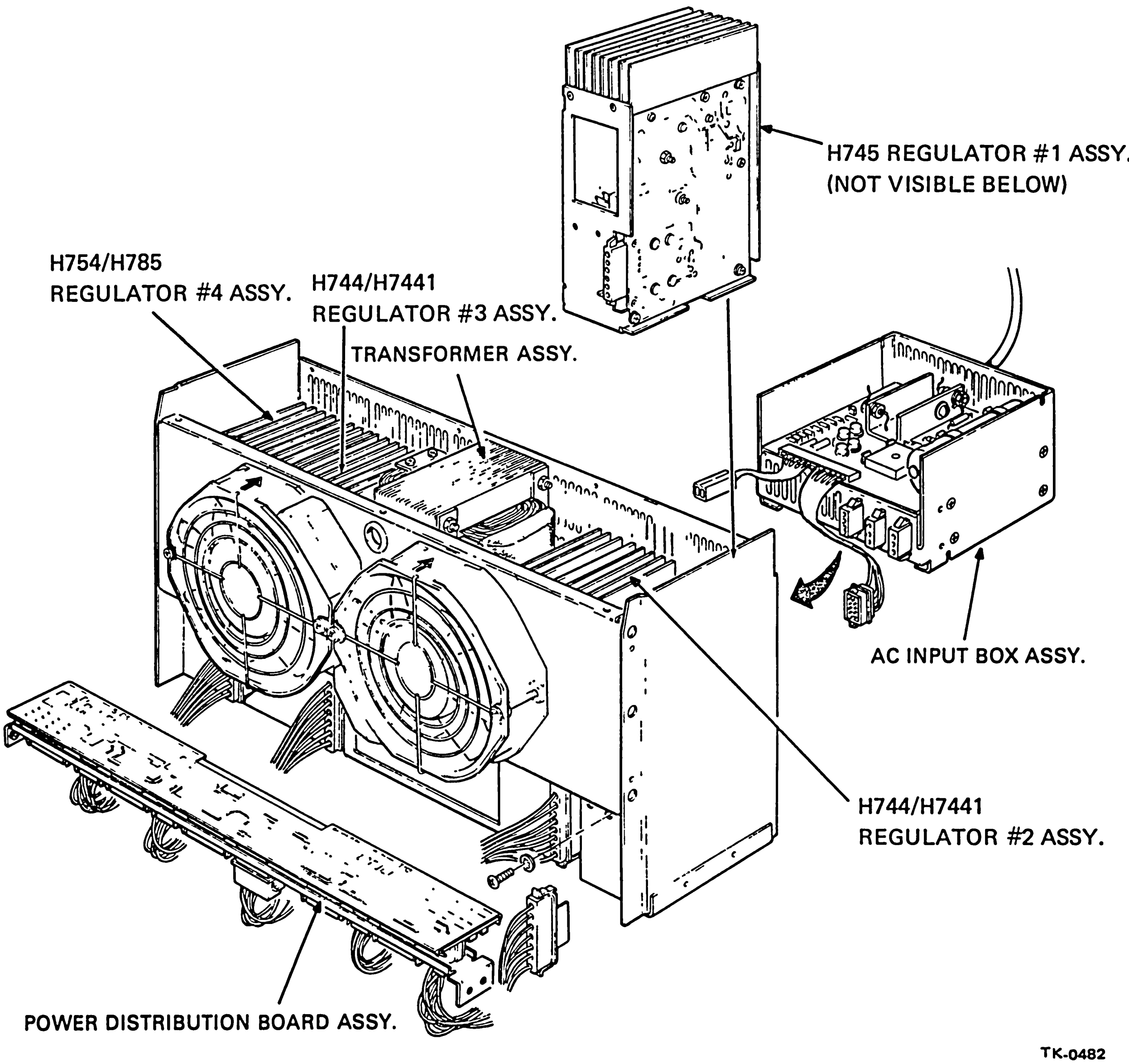


Figure 3-6 H765 Power Supply Assembly

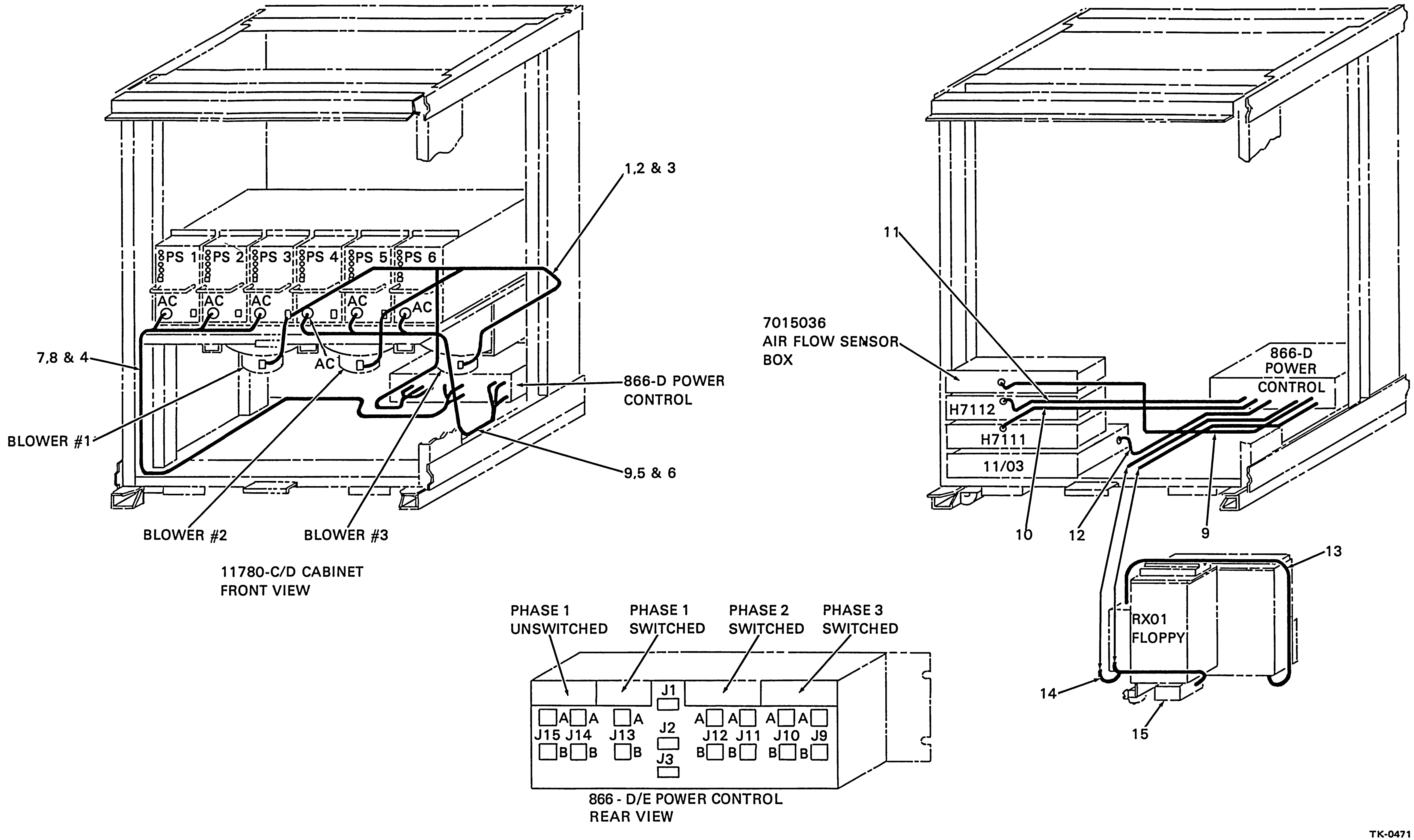


Figure 3-7 VAX-11/780-C/D Main Cabinet
(Front View) (Sheet 1 of 3)

11780 CA/DA 115 V.A.C 60HZ SYSTEM				
ITEM NO. (REF. ONLY)	PART NO.	DESCRIPTION	FROM	TO
1	7014323-06	POWER CORD ASSY (FAN 115 V)	CORD-P1	866-D J9-A
			-P2	BLOWER #1 J1
2	7014323-06	POWER CORD ASSY (FAN 115 V)	CORD-P1	866-D J15-A
			-P2	BLOWER #2 J1
3	7014323-06	POWER CORD ASSY (FAN 115 V)	CORD-P1	866-D J10-8
			-P2	BLOWER #3 J1
4	9107673-09	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J10-A
			-JACK	P.S. #2-AC
5	9107673-06	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J14-A
			-JACK	P.S.#4-AC
6	9107673-06	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J9-B
			-JACK	P.S. #5-AC
7	9107673-09	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J12-A
			-JACK	P.S. #3-AC
8	9107673-09	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J11-A
			-JACK	P.S. #1-AC
9	7015036-00	AIRFLOW SENSOR BOX	AC CORD-PLUG	866-D J11-B
10	H7111-A	T.O.D BATTERY	AC CORD-PLUG	866-D J15-B
11	H7112-A	MEMORY BATTERY	AC CORD-PLUG	866-D J14-B
12	PDP11/03 AA	16 BIT COMPUTER	AC CORD-PLUG	866-D J13-B
13	RX01-FA	RX01 FLOPPY U.A.	AC CORD-PLUG	RX01 RELAY-J1
14	9107673-03	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J13-A
			-JACK	RX01 RELAY-P1
15	7013928-00	FAN ASSY 115V	AC CORD-PLUG	866-D J12-B

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Figure 3-7 VAX-11/780-C/D Main Cabinet (Cabling Data) (Sheet 2 of 3)

	FOR 11780-C/D				
	ITEM NO. REF ONLY	PART NO.	DESCRIPTION	FROM	TO
	1	7014213-0K	CABLE, OVER TEMP.	PS #2-J4	PS #3-J4
	2	7014213-0K	CABLE, OVER TEMP.	PS #3-J5	PS #4-J5
	4	7014242-08	POWER CONTROL CABLE	866-J3	SCP-J1
PART OF KC780 ASSY	5	7-14243-21	FLOPPY RELAY SCP POWER HARNESS	HARN. -P2	KA780-J19
				-P1	SCP-J3
				-P3	RX01-J1
	6	7011411-12	CABLE, SIGNAL	KA780-J9	SCP-J2
PART OF KC780 ASSY	7	BC05L-10	CABLE	11/03 M9400-YE J1	KA780-J7
	8	BC05L-10	CABLE	11/03 M9400-YE J2	KA780-J8
	9	7014248-3M	CABLE, T.O.D. BATTERY	H7111-J1	KA780-J20

FOR 11780-C				
12	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #4-J4
11	7014213-3E	CABLE, OVER TEMP.	PS #2-J5	N.C.

OPTIONAL

FOR 11780-C WITH H7112				
12	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #4-J4
11	7014213-3E	CABLE, OVER TEMP.	H7112-J1	PS #2-J5
10	7014547-3D	CABLE, BATTERY OPTION	CABLE-P2	H7112-J7
			CABLE-P1	PS #4-BATT. ADAPT.

FOR 11780-C WITH FP780				
12	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #4-J4
14	7014213-0K	CABLE, OVER TEMP.	PS #1-J4	PS #2-J5
13	7014213-3E	CABLE, OVER TEMP.	PS #1-J5	N.C.

FOR 11780-C WITH H7112 & FP780				
12	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #4-J4
13	7014213-3E	CABLE, OVER TEMP.	H7112-J1	PS #1-J5
14	7014213-0K	CABLE, OVER TEMP.	PS #1-J4	PS #2-J5
10	7014547-3D	CABLE, BATTERY OPTION	CABLE-P2	H7112-J7
			CABLE-P1	PS #4 BATT. ADAPT.

NOTE: * CONN. J8 ON ADAPTER CABLE (7015155) SNAPS INTO CUTOUT ON EXPANDER I/D CONN. PANEL.

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Figure 3-7 VAX-11/780-C/D Main Cabinet (Cabling Data) (Sheet 3 of 3)

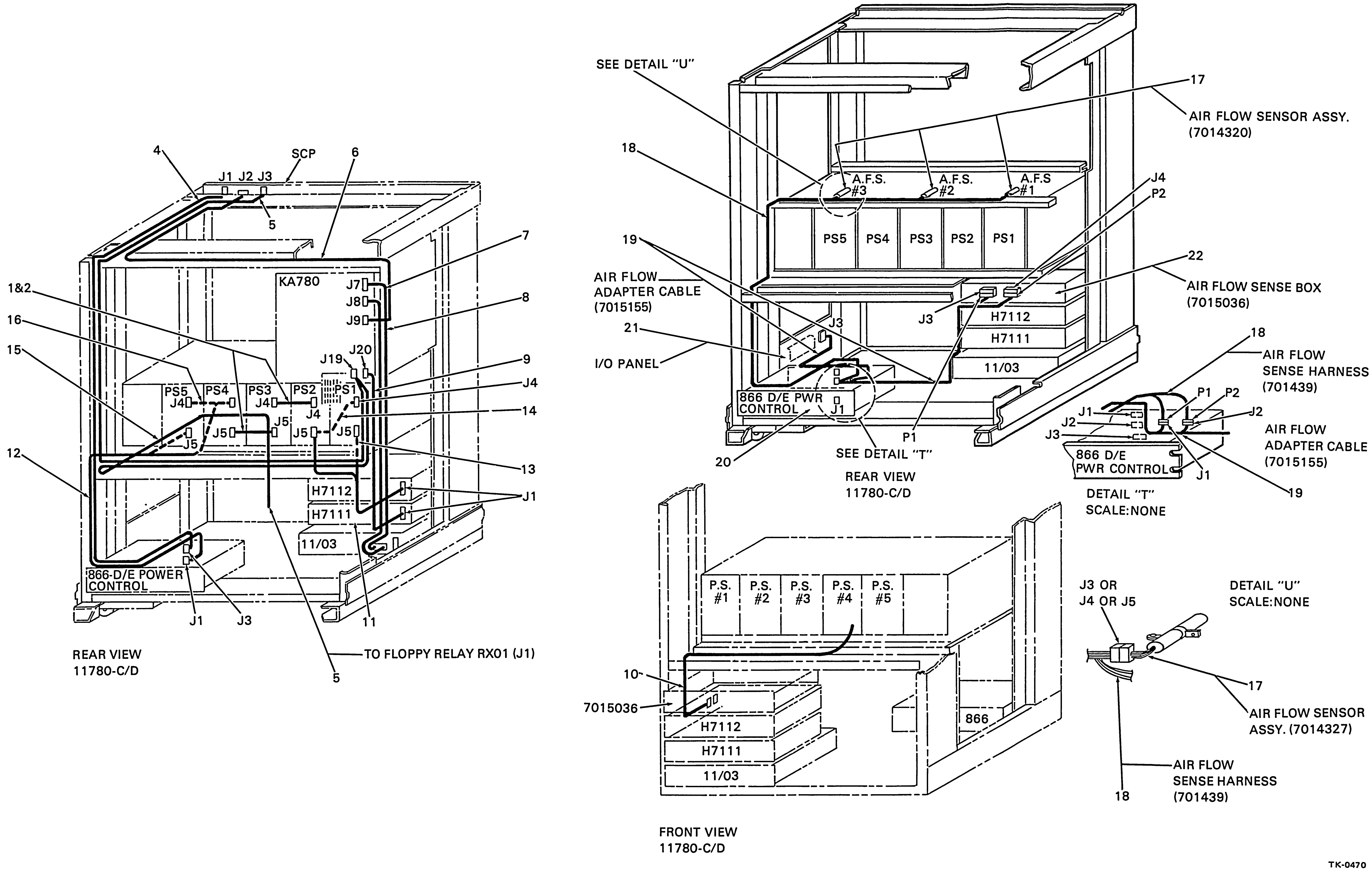

Figure 3-8 VAX 11/780-C/D Main Cabinet (Rear View) (Sheet 1 of 3)

11780 CC/DC 115VAC 50 HZ SYSTEM				
ITEM NO. (REF ONLY)	PART NO.	DESCRIPTION	FROM	TO
1	7014323-06	POWER CORD ASSY (FAN 115V)	CORD-P1	866-D J9-A
			-P2	BLOWER #1 J1
2	7014323-06	POWER CORD ASSY (FAN 115V)	CORD-P1	866-D J15-A
			-P2	BLOWER #2 J1
3	7014323-06	POWER CORD ASSY (FAN 115V)	CORD-P1	866-D J10-8
			-P2	BLOWER #3 J1
4	9107673-09	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J10-A
			-JACK	P.S. #2-AC
5	9107673-06	EXTENSION CORD 115V 15A	CORD PLUG	866-D J14-A
			-JACK	P.S. #4-AC
6	9107673-06	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J9-B
			-JACK	P.S. #5-AC
7	9107673-09	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J12-A
			-JACK	P.S. #3-AC
8	9107673-09	EXTENSION CORD 115V 15A	CORD-PLUG	866-D J11-A
			-JACK	PS #1-AC
9	7015036-00	AIR FLOW SENSOR BOX	AC CORD-PLUG	866-D J11-B
10	H7111-A	T.O.D. BATTERY	AC CORD-PLUG	866-D J15-B
11	H7112-A	MEMORY BATTERY	AC CORD-PLUG	866-D J13-B
12	PDP 11/03-AA	16 BIT COMPUTER	AC CORD-PLUG	RX01 RELAY-J1
13	RX01-FC	RX01 FLOPPY U.A.	CORD-PLUG	866-D J13-A
14	9107673-03	EXTENSION CORD 115V 15A	CORD-JACK	RX01 RELAY-P1
15	7013928-00	FAN ASSY 115V	AC CORD-PLUG	866-D J12-B

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Figure 3-8 VAX-11/780-C/D Main Cabinet (Cabling Data) (Sheet 2 of 3)

FOR 11780-D				
ITEM NO. REF. ONLY	PART NO.	DESCRIPTION	FROM	TO
16	7014213-0K	CABLE, OVER TEMP.	PS #4-J4	PS #5-J4
15	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #5-J5
11	7014213-3E	CABLE, OVER TEMP.	PS #2-J5	N.C.

FOR 11780-D WITH H7112				
16	7014213-0K	CABLE, OVER TEMP.	PS #4-J4	PS #5-J4
15	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #5-J5
11	7014213-3E	CABLE, OVER TEMP.	PS #2-J5	H7112-J1
10	7014547-3D	CABLE, BATTERY OPTION	CABLE-P2	H7112-J7
			CABLE-P1	PS #4 BATT. ADAPT.

FOR 11780-D WITH FP780				
16	7014213-0K	CABLE, OVER TEMP.	PS #4-J4	PS #5-J4
15	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #5-J5
13	7014213-3E	CABLE, OVER TEMP.	PS #1-J5	N.C.
14	7014213-0K	CABLE, OVER TEMP.	PS #1-J4	PS #2-J5

FOR 11780-D WITH H7112 & FP780				
16	7014213-0K	CABLE, OVER TEMP.	PS #4-J4	PS #5-J4
15	7014213-4A	CABLE, OVER TEMP.	866-J1	PS #5-J5
13	7014213-3E	CABLE, OVER TEMP.	H7112-J1	PS #1-J5
14	7014213-0K	CABLE, OVER TEMP.	PS #1-J4	PS #2-J5
10	7014547-3D	CABLE, BATTERY OPTION	CABLE-P2	H7112-J7
			CABLE-P1	PS #4 BATT. ADAPT.

INTERCONNECTION TABLE FOR 11780-C/D							
FROM				TO			
ITEM NO.	PART NO	DESCRIPTION	CONN	ITEM NO.	PART NO.	DESCRIPTION	CONN
17	7014320	AIRFLOW SENSOR #3	P1	18	7014319	AIRFLOW SENSE HARN.	J3
17		AIRFLOW SENSOR #2	P1	18			J4
17		AIRFLOW SENSOR #1	P1	18			J5
19	7015155	AIRFLOW ADAPTER CABLE	J1	18			P1
19			J2	18			P2
19			P3	20	866-D/E	PWR CONTROL BOX	J2
19			J8	21		I/O CONNECTOR PANEL	•
19			P1	22	7015036	AIRFLOW SENSOR BOX	J3
19			P2	22			J4

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Figure 3-8 VAX-11/780-C/D Main Cabinet (Cabling Data) (Sheet 3 of 3)

Table 3-1 Standard DEC Power Controllers Used in VAX-11/780 Systems

Type	Voltage	Frequency (Hz)	Phase(s)	A/Phase	CB Poles	Max. Load kVA
869B	240	47–63	Single	16	4	3.83
869C	120	47–63	Single	24	4	2.88
869D	120/208	47–63	Three	24	4	8.64
869E	240/416	47–63	Three	12	4	8.64
866D	120/208	47–63	Three	24	4	8.64
866E	240/416	47–63	Three	12	4	8.64
861B	240	47–63	Single	16	3	3.83
861C	120	47–63	Single	24	3	2.87

Table 3-2 Power Cords, Plugs and Receptacles for Controllers Used in VAX-11/780 Systems

Three Phase Controllers

Type	Power Cord* and Plug Assy. No.	Wires	Plug No. DEC	NEMA	Hubbell	Receptacle** No. DEC	Receptacle** No. NEMA	Hubbell
869D†	7015253	5 #10	12-12314	L21-30P	2811	12-12315	L21-30R	2810
869E†	7015254	5 #14	12-14379-0	N/A	520P7	12-14378-02	N/A	520R7
866D†	7015253	5 #10	12-12314	L21-30P	2811	12-12315	L21-30R	2810
866E†	7015254	5 #14	12-14034	L22-30P	2521	12-14033	L22-20R	2520

Single-Phase Controllers

Type	Power Cord* and Plug Assy. No.	Wires	Plug No. DEC	Plug No. NEMA	Plug No. Hubbell	Receptacle** No. DEC	Receptacle** No. NEMA	Hubbell
869B	7015474		12-14379-03	N/A	320P6	12-14378-03	N/A	320R6
869C	7015253		12-11193	L5-30P	2611	12-11194	L5-30R	2610
861B	N/A	3 #	12-11192	L6-20P	2321	12-11191	L6-20R	2320
861C	N/A	3 #	12-11193	L5-30P	2611	12-11194	L5-30R	2610

*Cord length is 4.5 m (15 ft).

†For controllers supplied without power cord, input connections are to five 10–32 studs.

**Receptacles are DEC supplied with 869B and 869E controllers only.

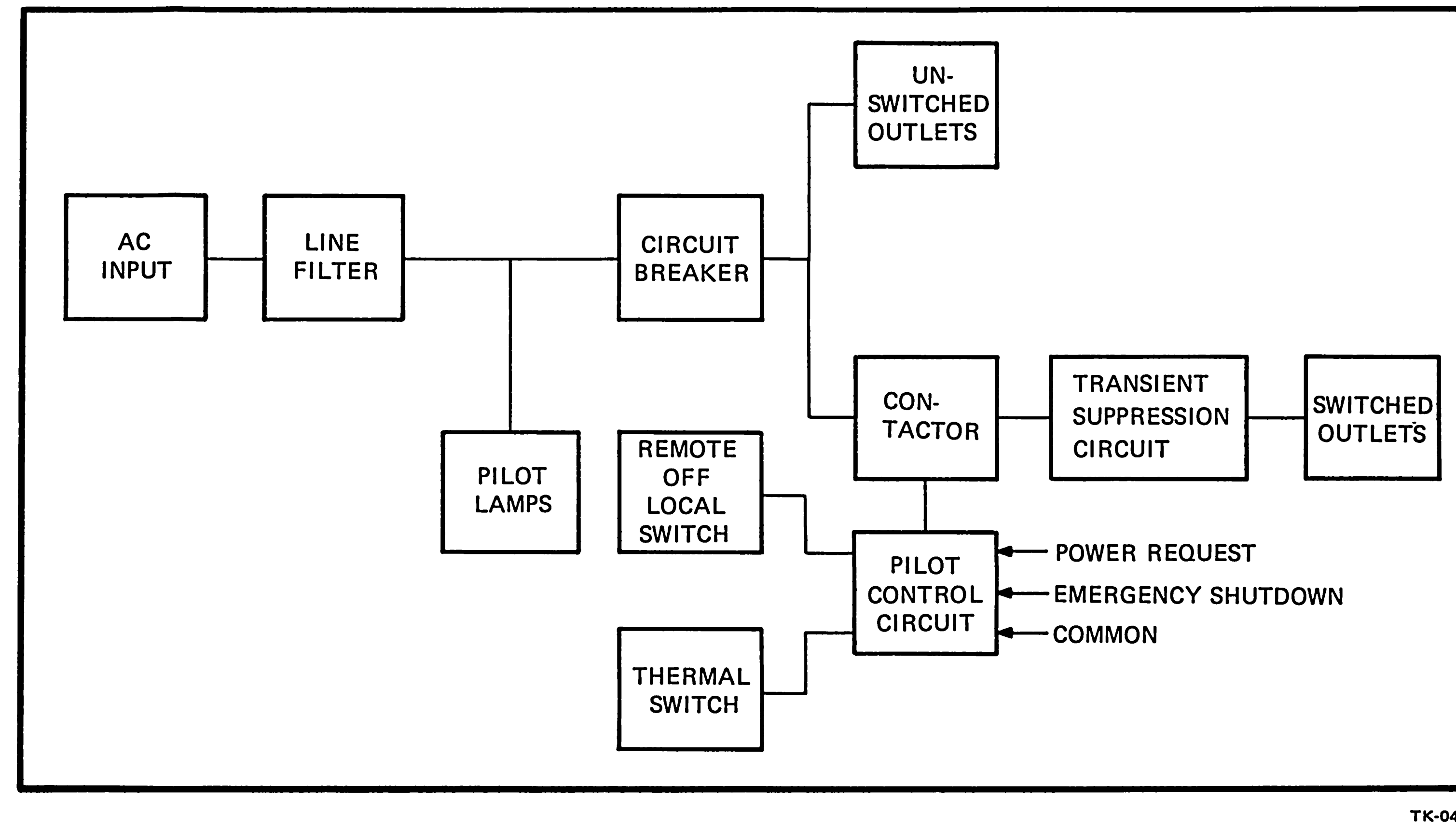

Figure 3-9 Simplified Block Diagram –
866 and 861 Power Controllers

3.2.1 Power Control Bus

Power controllers interconnected by the power control bus accomplish the following basic functions.

1. Control of large amounts of power by control signals of relatively low power level.

2. Convenient distribution of primary power to controlled devices.

3. Filtering of all primary power to protect data from noise effects.

4. Automatic removal of primary power in the event of overload or overtemperature conditions.

5. Isolation of portions of the power distribution system to permit servicing of discrete areas without interrupting total system operation.

The power control bus is a series of 3-wire cables harnessed for interconnection of all power controllers in the central processor cabinet array. Parallel-wired 3-pin Mate-N-Lok connectors at the rear of each controller (refer to J4, J5, and J6 in Figure 3-15) are used to interconnect the controllers and the main cabinet control panel (refer to Figure 3-1). The operation of the power control bus is as follows.

1. Connection of line 1 (POWER REQUEST) to line 3 (ground) energizes the contactor through the pilot control board to cause ac power to be applied to the switched outlets. Whenever the controller's LOCAL/OFF/REMOTE switch (Figure 3-12) is in its LOCAL position, lines 1 and 3 are connected.

2. Connection of line 2 (EMERGENCY SHUTDOWN) to line 3 (ground) causes disconnect of all power to the controller's switched outlets.

3.2.2 AC Power Distribution with 866 and 861 Power Controllers

Figure 3-10 is a single-line diagram showing the ac power distribution for VAX-11/780 systems in which the central processor cabinets (main cabinet, expander cabinets, tape drive cabinets) use the 866 3-phase and 861 single-phase controllers. The 866D is for 120/208 Vac, 47–63 Hz primary power and the 866E for 240/416 Vac, 47–63 Hz. The 861C operates off single-phase 120 Vac and the 861B off 240 Vac primary power.

In the figure, note that the controller receptacles (J9 through J15) are the outlets shown on the rear-view drawing of the 866 (Figure 3-21). Receptacle numbers and locations are identical on both the 866D and 866E; however, the polarization for the 866D outlets is 120 Vac and 866E is 240 Vac.

As shown in the diagram, the unswitched phase provides ac power to: the H7112 Battery Backup Power Supply option at J14B, the No. 4 power supply feeding dc voltages to the MS780A memory at J14A, the H7111 Time-of-Day Clock Battery Backup power supply at J15B, and the No. 2 blower (located above the memory dc power supply) at J15A.

The devices on the unswitched phase continue to operate in the 866/861 controller configuration even after EMERGENCY SHUTDOWN has been commanded on the power control bus.

The expander cabinet configuration is only one of several possible combinations, but the basic inter-controller relationship still holds.

Also physically situated outside the controller block are the power supply thermal sensors; each supply has a single thermal sensor located on its output transistor heat sink. The main cabinet air flow sensors (3 in the VAX-11/780 main cabinet) are located just below the card cage in the narrow space separating the bottom of the cage from the tops of the power supplies. Seen from the front or rear of the

cabinet, each sensor is located above one of the three blowers. These locations provide optimum sensing of air velocity and temperature as the downward flow of cooling air leaves the modules in the card cage.

Note that the primary power control originates at the key-operated switch on the control panel of the main cabinet, passes through the pilot control circuit, and energizes or deenergizes the contactor controlling the primary power flow to the "switched" receptacles. Figure 3-11 shows the ac power distribution details for the 3-phase, 120 Vac, 60 Hz system. Similar drawings for the 3-phase 120 Vac and 240 Vac, 50 Hz systems are included in the print set.

AC power distribution in each controller follows this basic sequence:

1. A 3-phase line filter removes high frequency components entering the system via the primary power source.

2. An indicating lamp in each hot leg of the 3-phase supply illuminates when the power plug of the power controller is plugged into the customer's receptacle.

3. A 3-phase circuit breaker applies power to the unswitched outlets or, as in the case of the 869D, which has an individual circuit breaker for each duplex outlet, to the outlet CBs. This power is also applied to the input contacts of the 3-phase contactor.

4. When the contactor is energized (closed) by command from the control board, power is also applied to the individual outlet CBs grouped under the heading of "switched" outlets.

5. With all outlet CBs in the closed position, single phase 120 Vac (869D controller) or 240 Vac (869E controller) is applied to the equipment plugged into the receptacles of the power controller.

6. Since the power controllers of the main cabinet and expansion cabinet are interconnected via the DEC power control bus, the equipment in all other central processor cabinets comes on at the same time as the equipment in the main cabinet to render the system operational. Peripherals are individually supplied with primary power from customer receptacles, and are manually switched on.

NOTE

The 869 controller provides an optional 1/2 second turn-on delay before any power-up or power-down command is transmitted to the next cabinet.

3.2.3 AC Power Distribution of Systems Using 869 3-Phase and Single Phase Power Controllers

Figure 3-12 is a single-line diagram showing the ac power distribution for VAX-11/780 systems in which the central processor cabinets use the 869-series 3-phase and single-phase controllers. The 869D is for 120/208 Vac, 47–63 Hz primary power; i.e., is the conterpart of the 866D. Similarly, the 869E is the counterpart of the 240/416 Vac, 47–63 Hz 866E. Figure 3-13 is a simplified block diagram of the 869 family of controllers, while Figures 3-14 through 3-28 (exclusive of Figure 3-22, the Air Flow Interface) show the front and rear features of the 869, 866 and 861 controllers. Since the 861s do not have rear receptacles, only their front views are shown.

The 869C (Figure 3-23) corresponds to the 120 Vac, 47–63 Hz, single phase 861C (Figure 3-27) and the 869B (Figure 3-25) corresponds to the 230 Vac, 47–63 Hz, 861B single-phase controller (Figure 3-28).

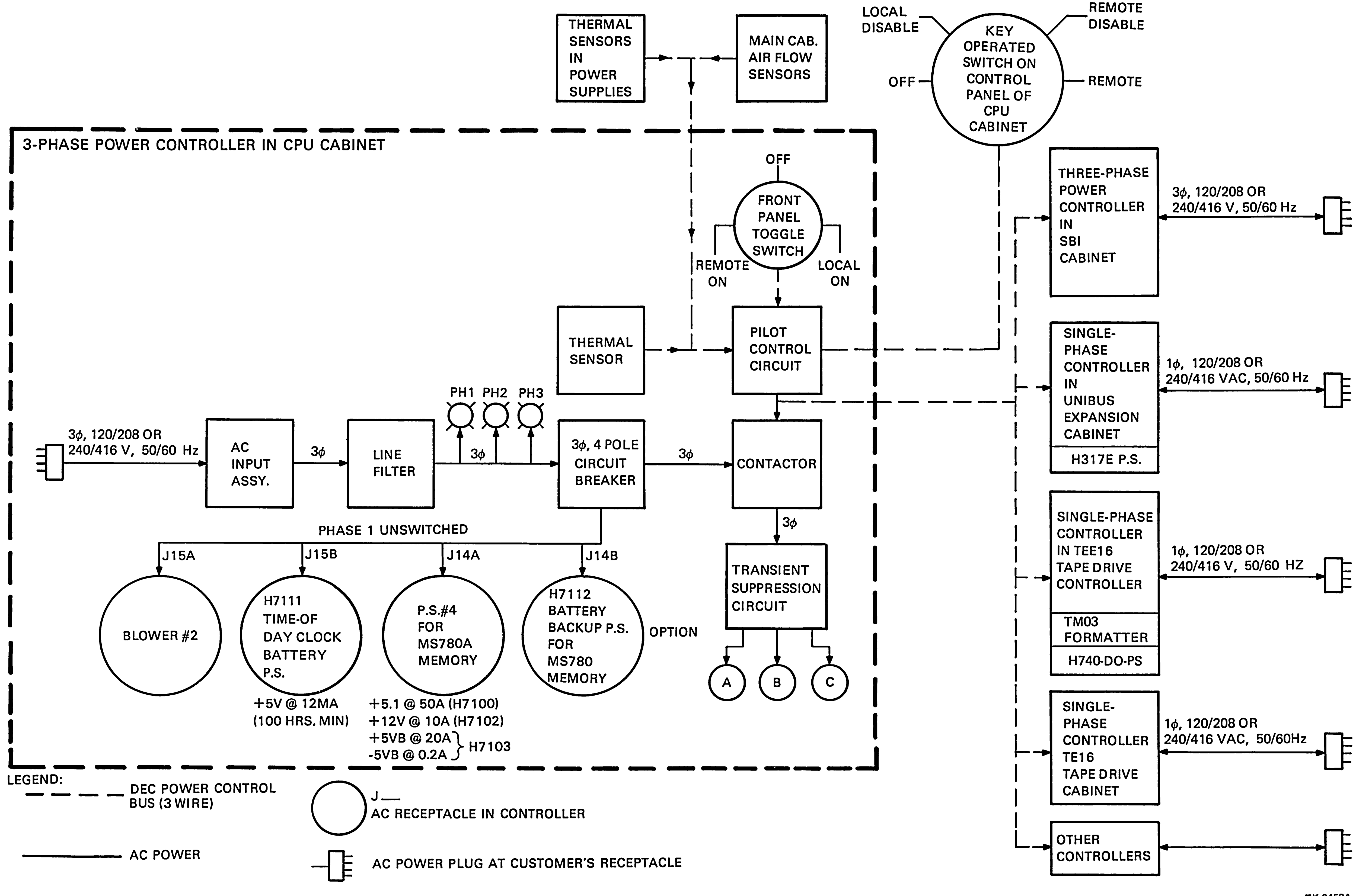

Figure 3-10 VAX-11/780 AC Power Distribution System Using the 866 (3-Phase) and 861 (Single-Phase) Power Controllers (Sheet 1 of 2)

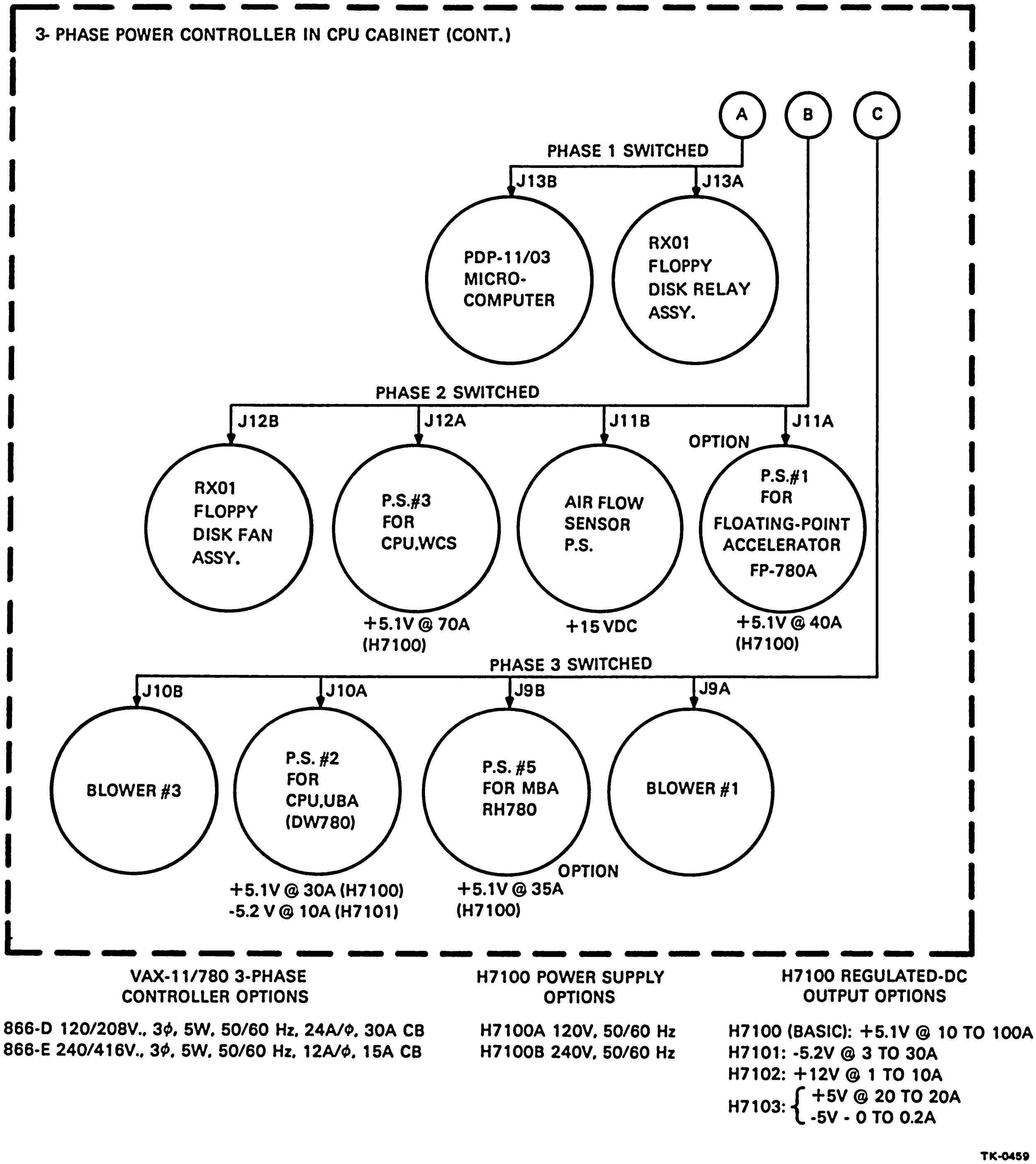

Figure 3-10 VAX-11/780 AC Power Distribution System Using the 866 (3-Phase) and 861 (Single-Phase) Power Controllers (Sheet 2 of 2)

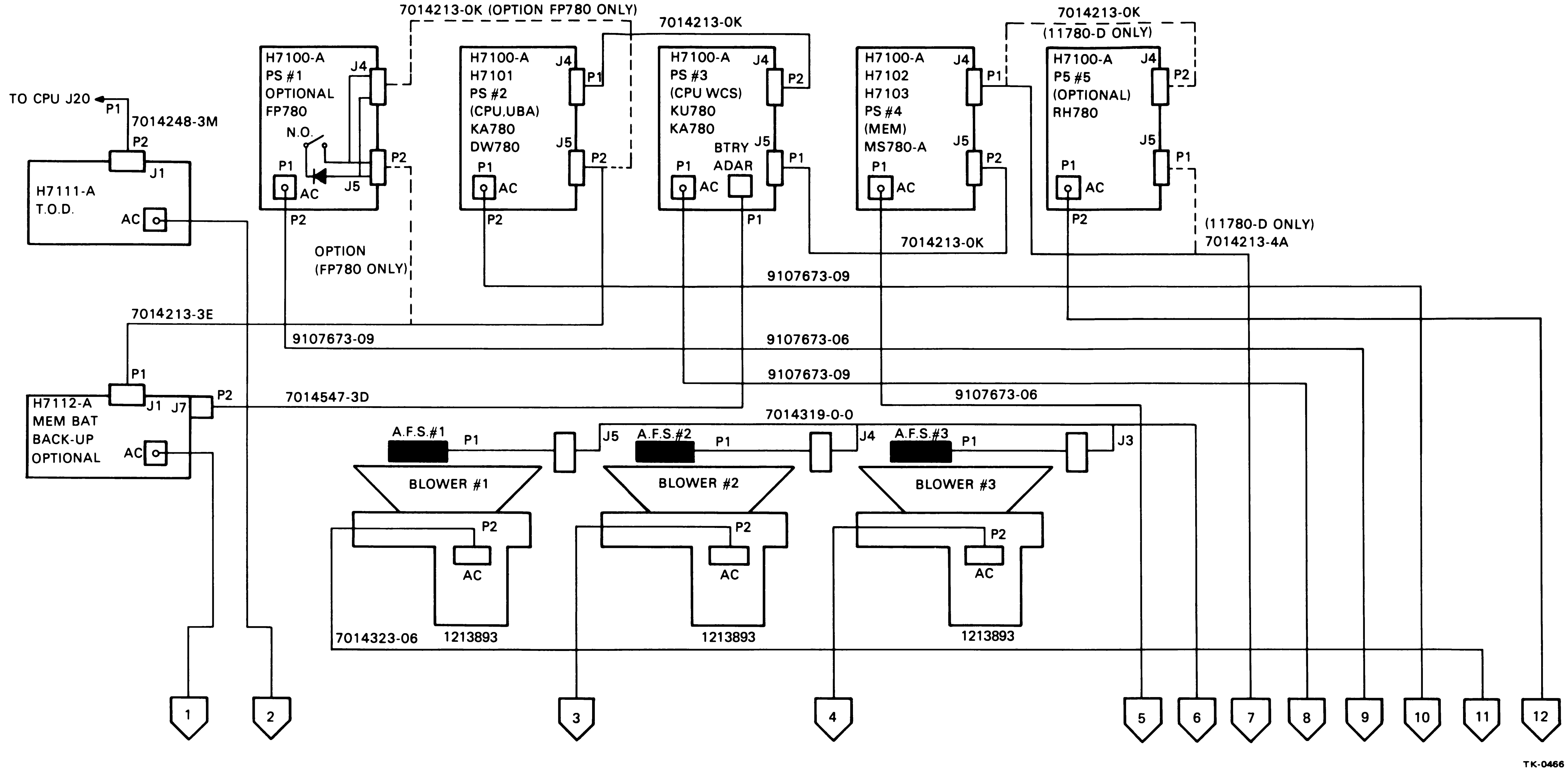

Figure 3-11 VAX-11/780 Main Cabinet Power Distribution (3-Phase, 120 Vac, 60 Hz) (Sheet 1 of 2)

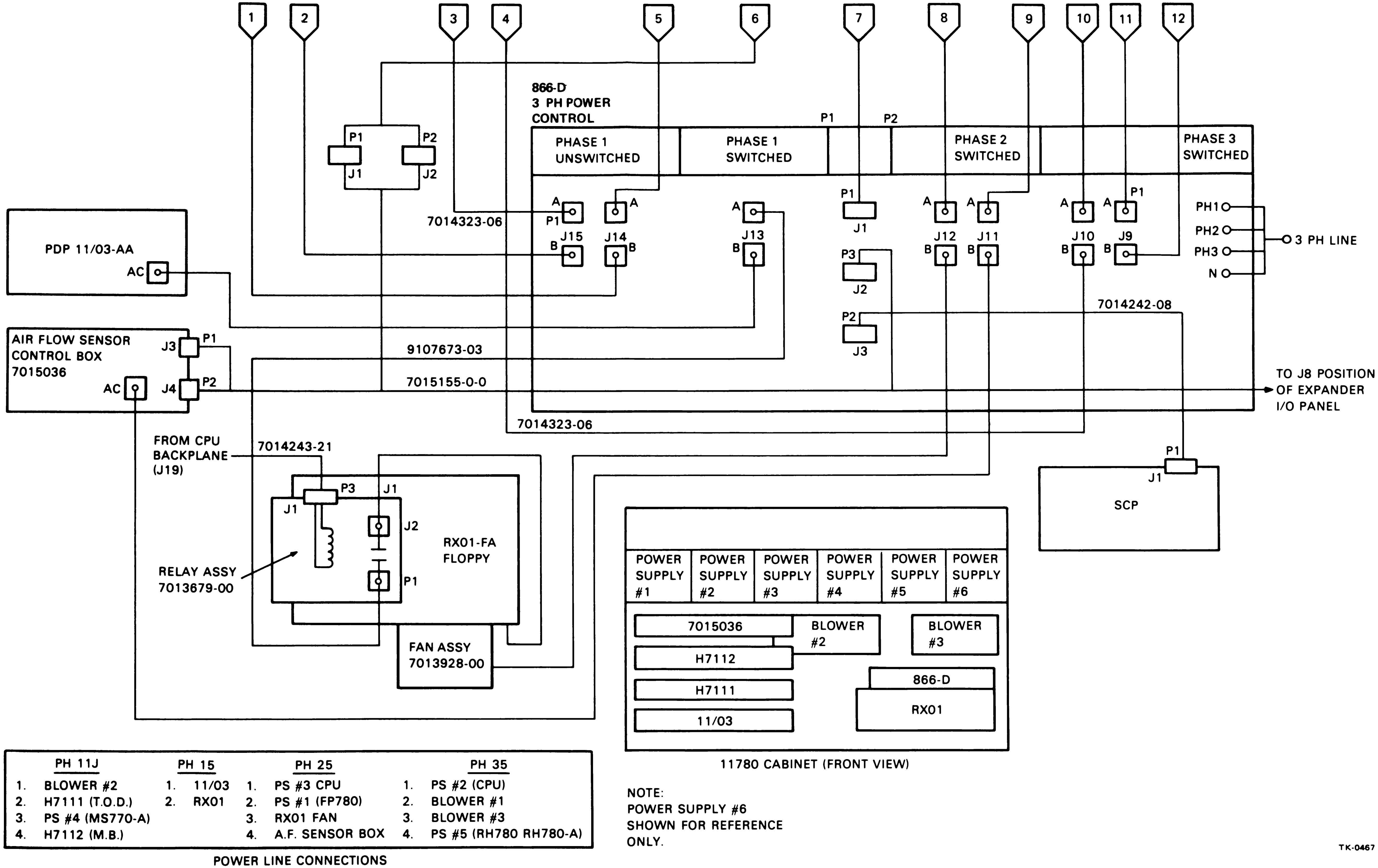

Figure 3-11 VAX-11/780 Main Cabinet Power Distribution (3-Phase, 120 Vac, 60 Hz) (Sheet 2 of 2)

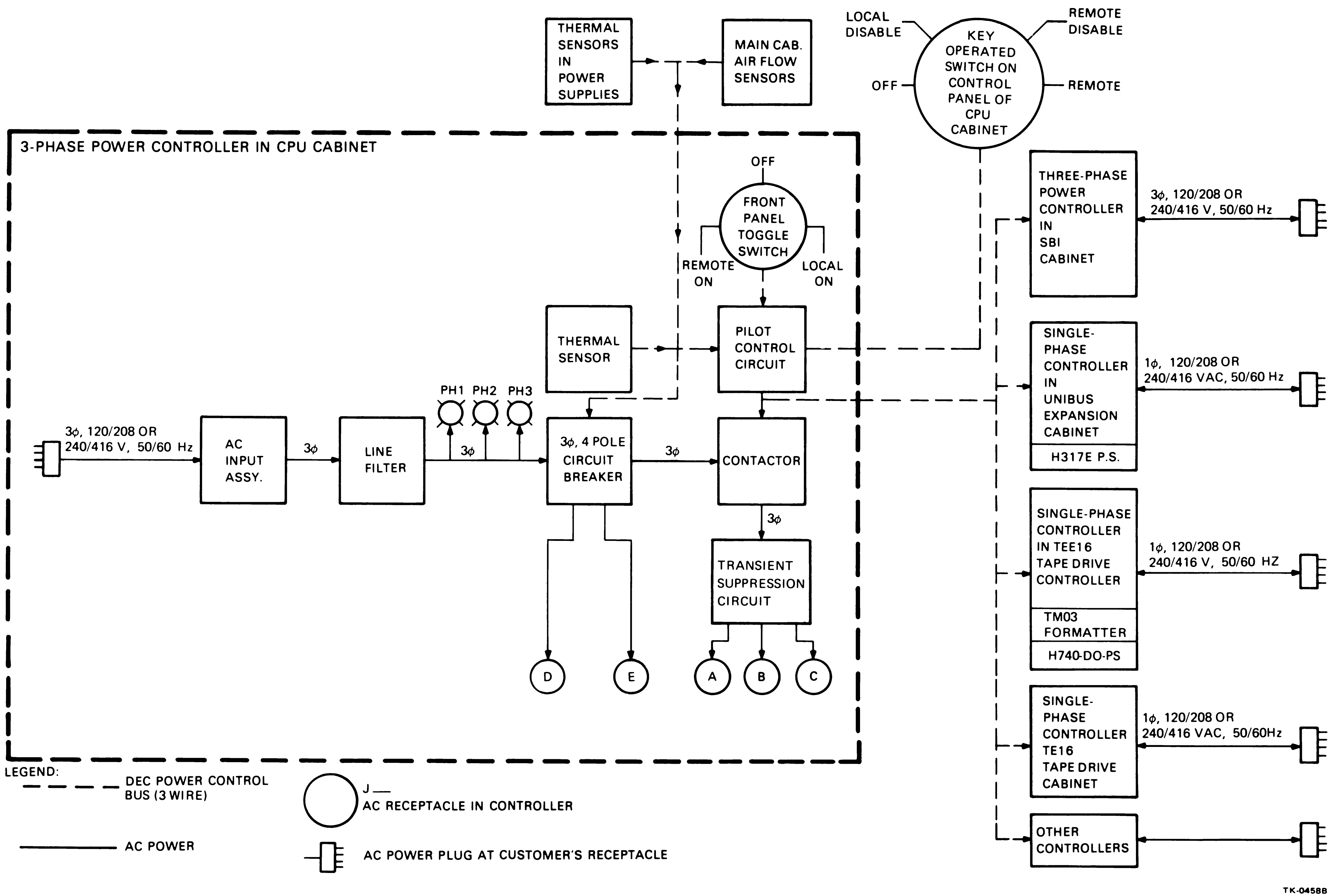

Figure 3-12 VAX-11/780 AC Power Distribution System Using the 869 3-Phase Power Controller (Sheet 1 of 2)

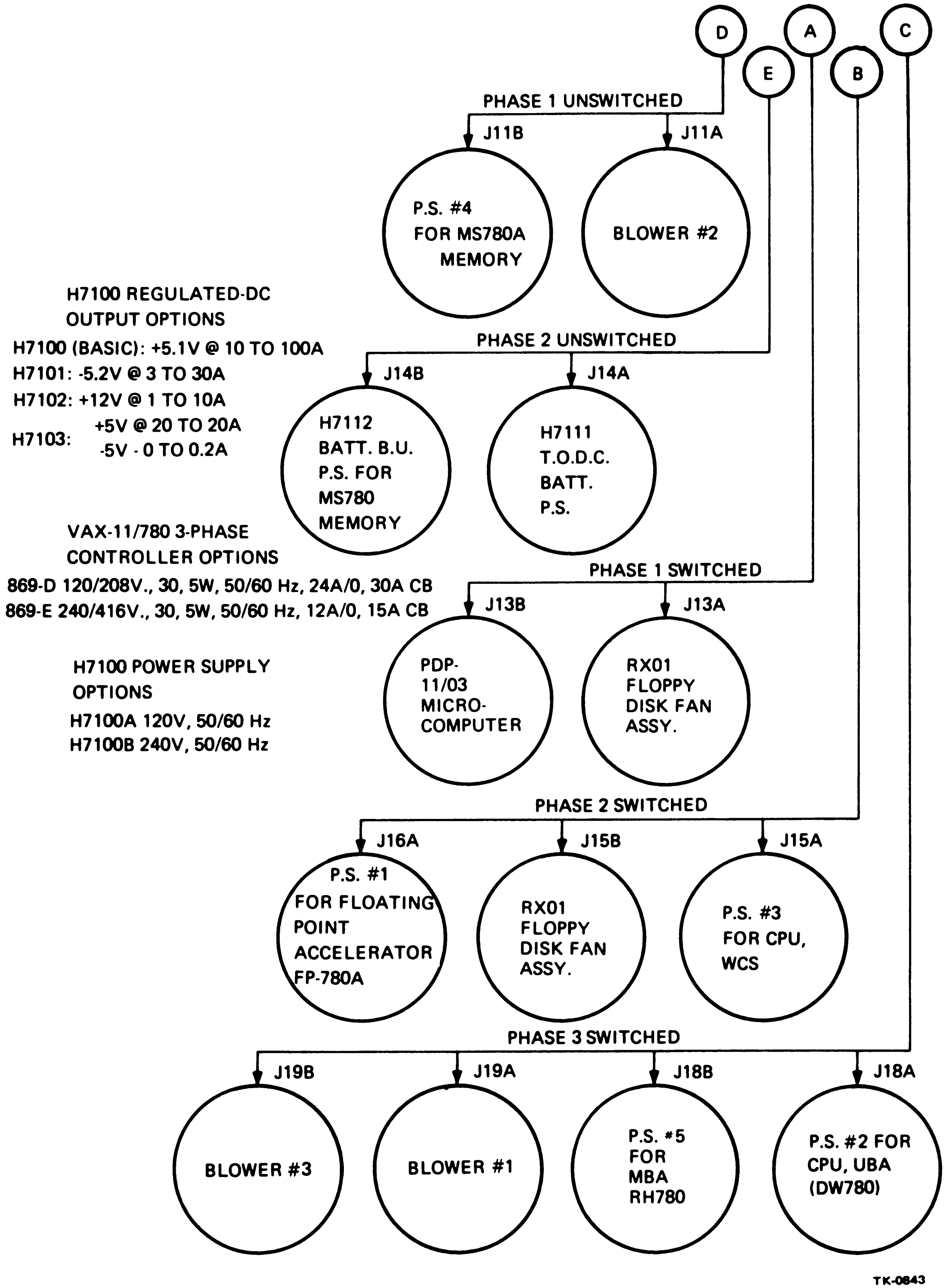

Figure 3-12 VAX-11/780 AC Power Distribution System Using the 869 3-Phase Power Controller (Sheet 2 of 2)

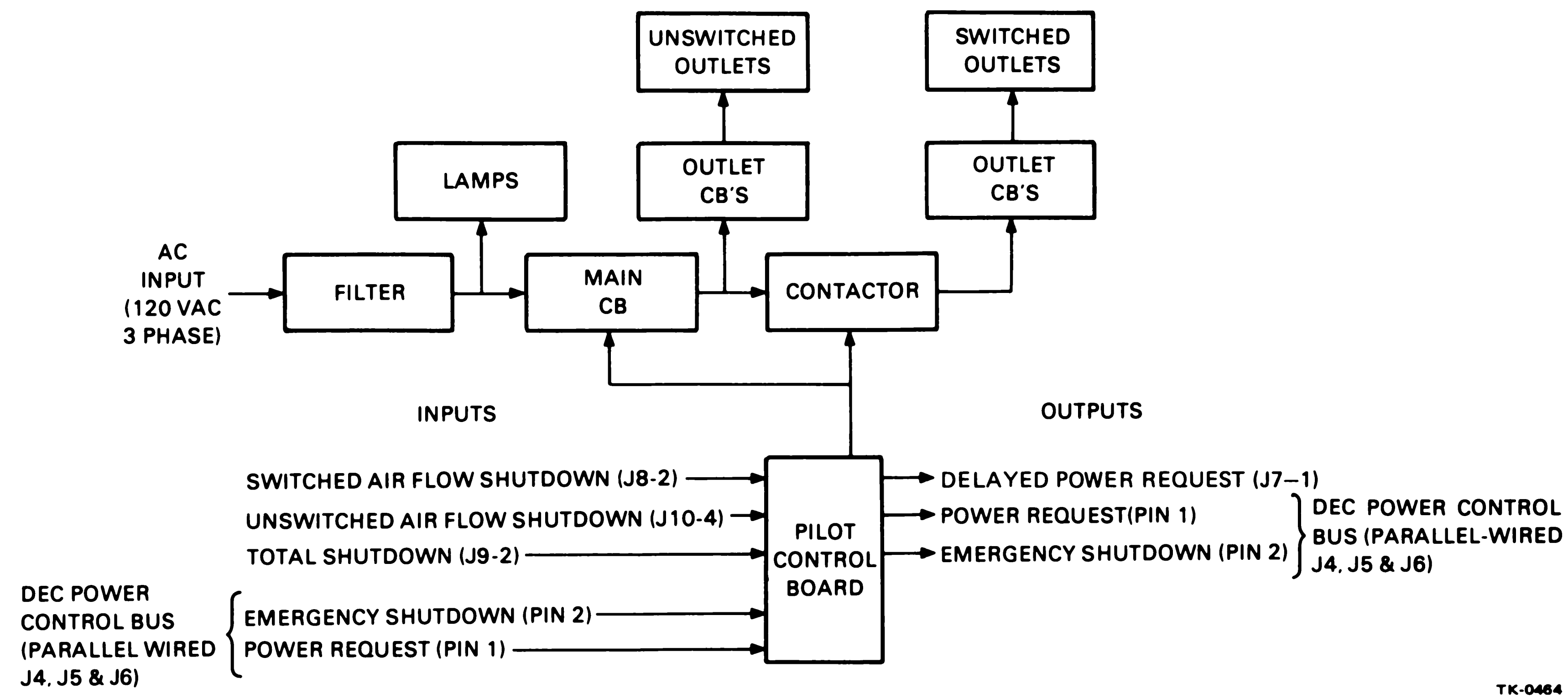

Figure 3-13 869 Power Controller – Simplified Block Diagram

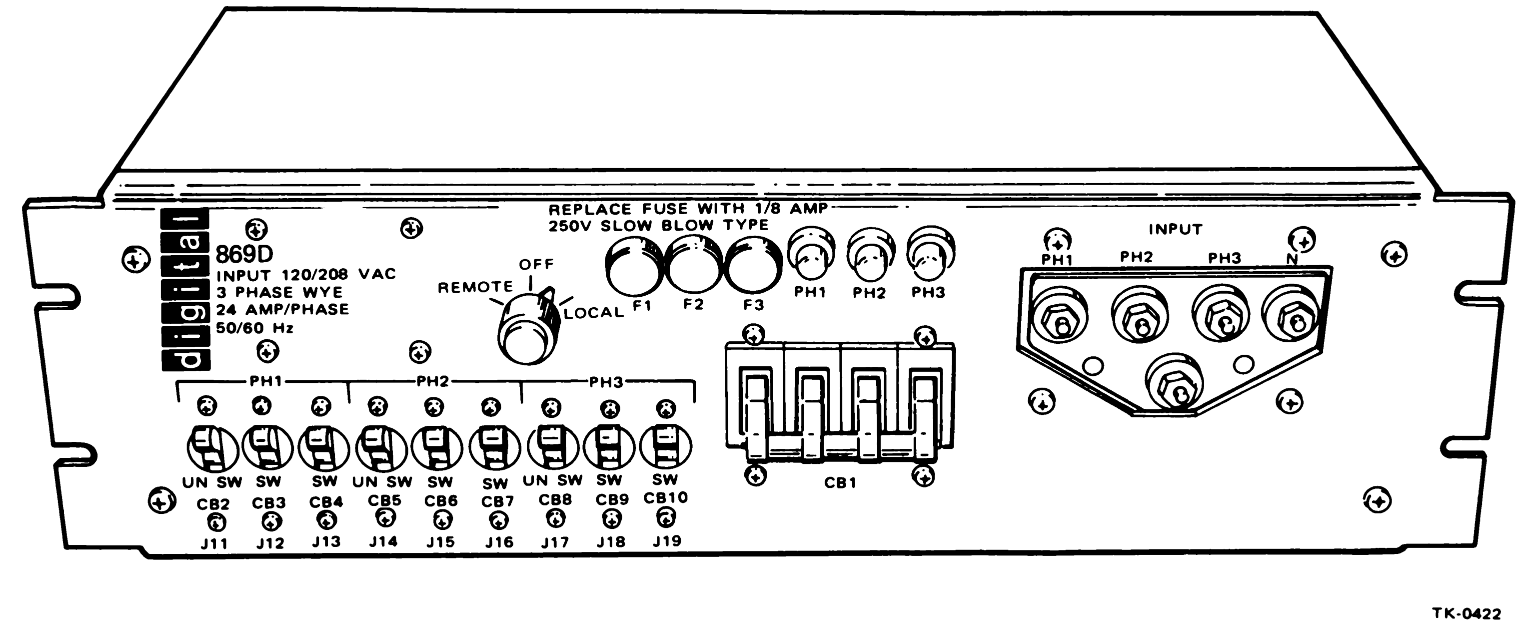

Figure 3-14 869D Power Controller (Front View)

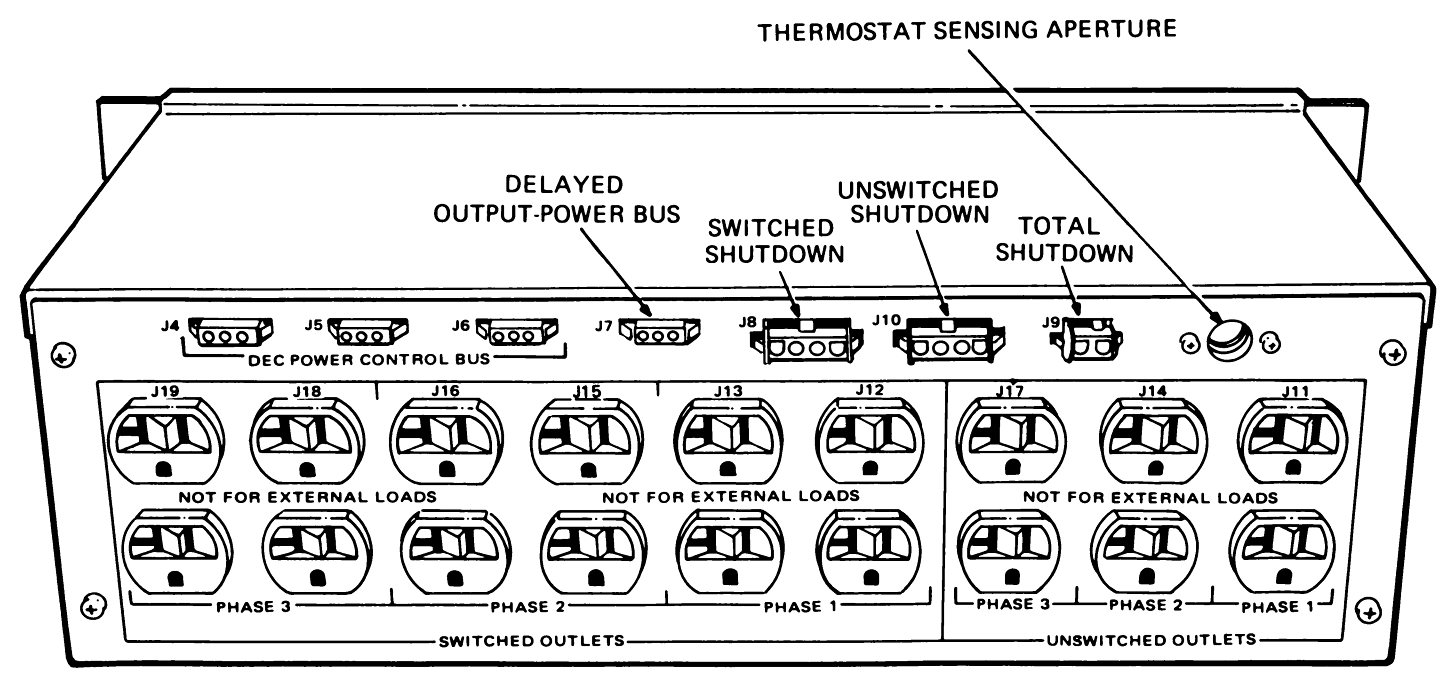

Figure 3-15 869D Power Controller (Rear View)

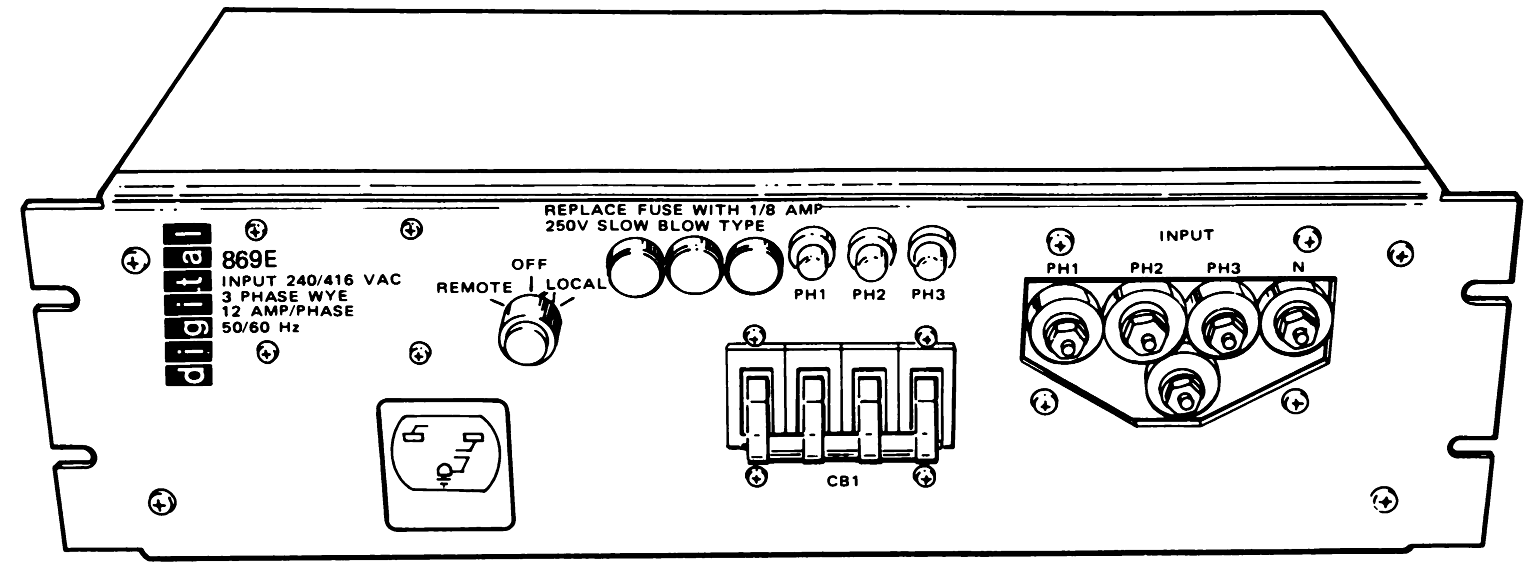

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Figure 3-16 869E Power Controller (Front View)

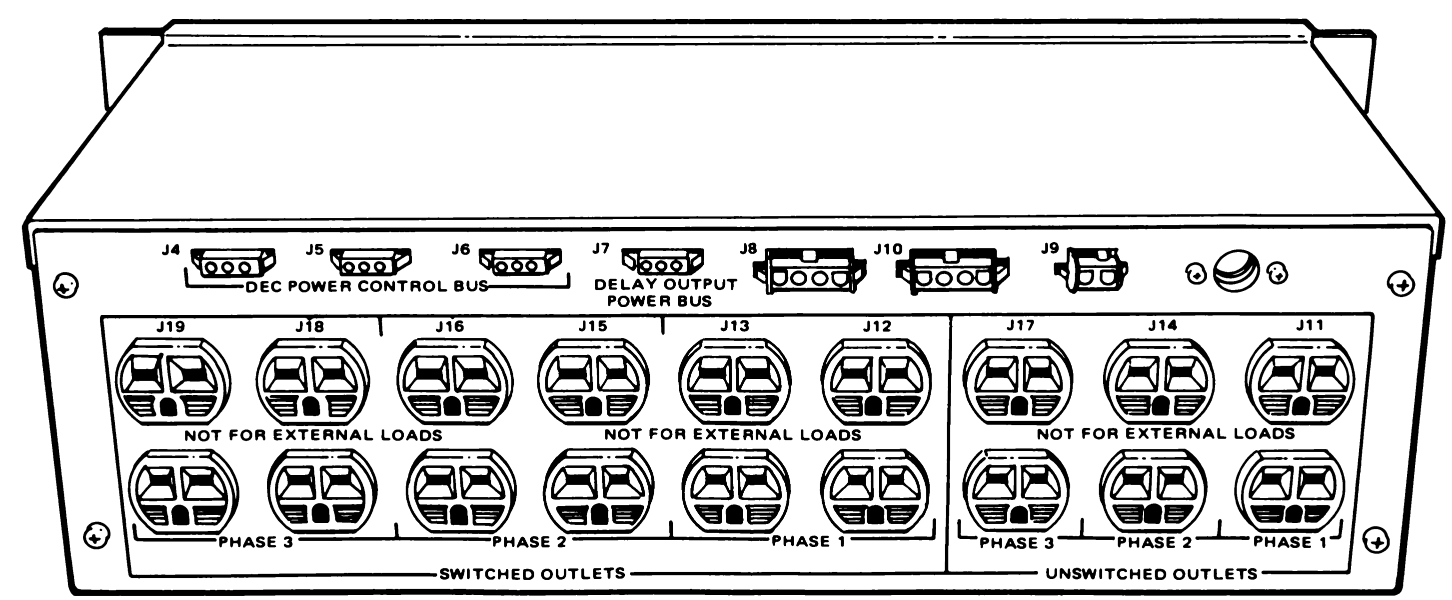

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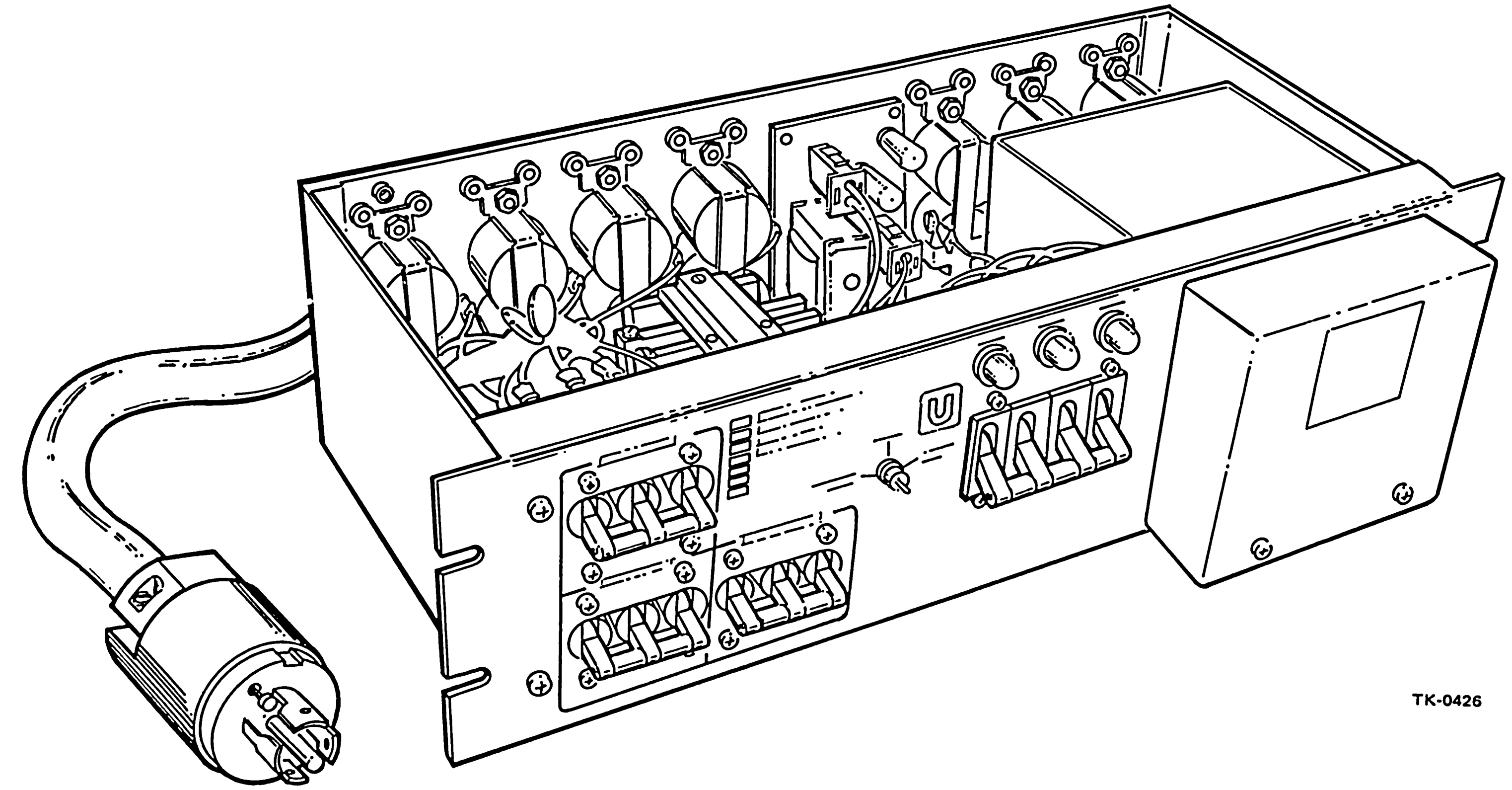
Figure 3-17 869E Power Controller (Rear View)



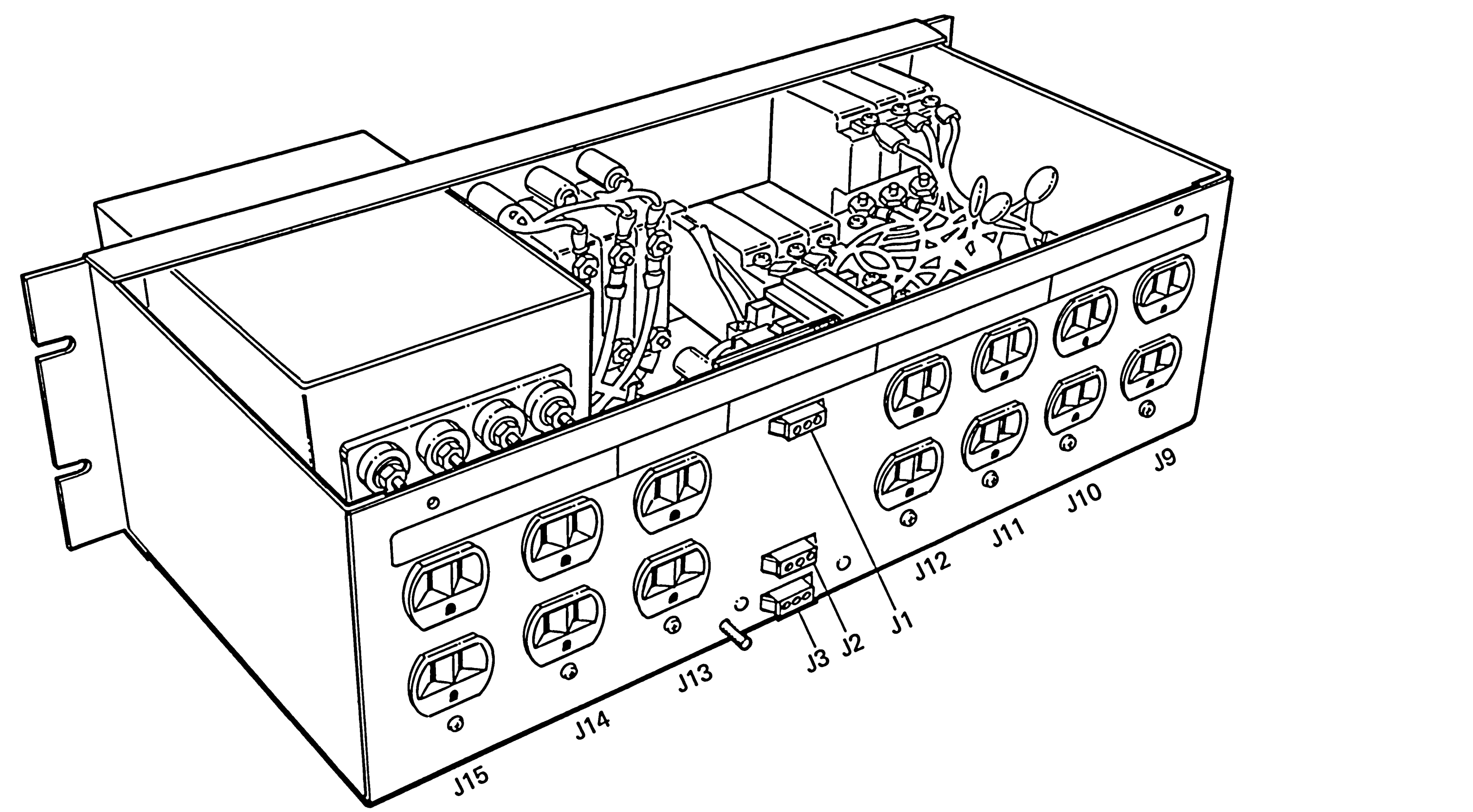


Figure 3-19 866D Power Controller (Rear View)

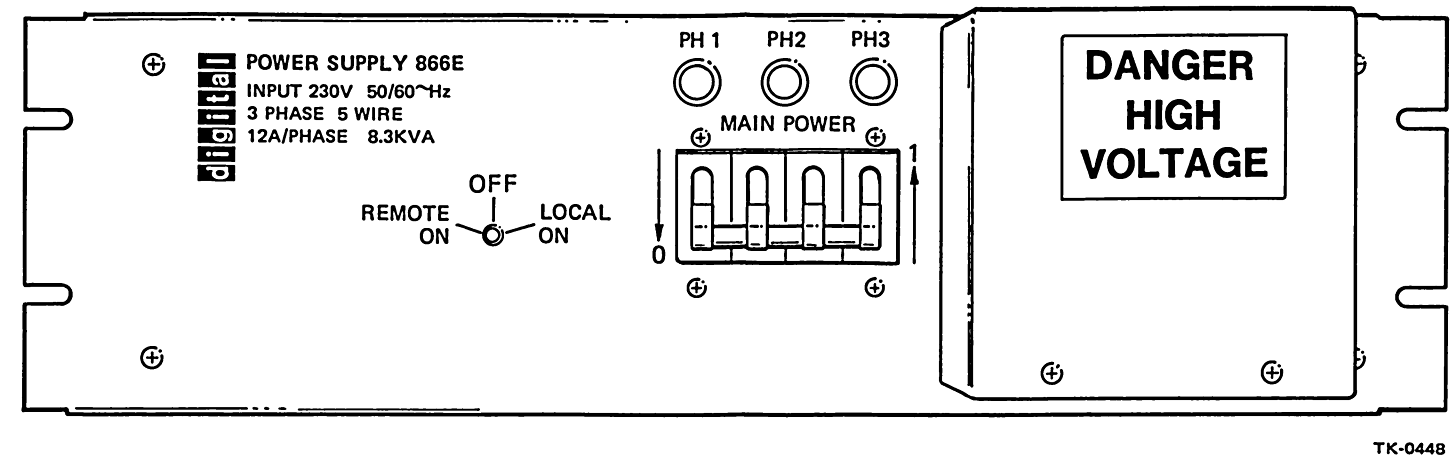


Figure 3-20 866E Power Controller (Front View)

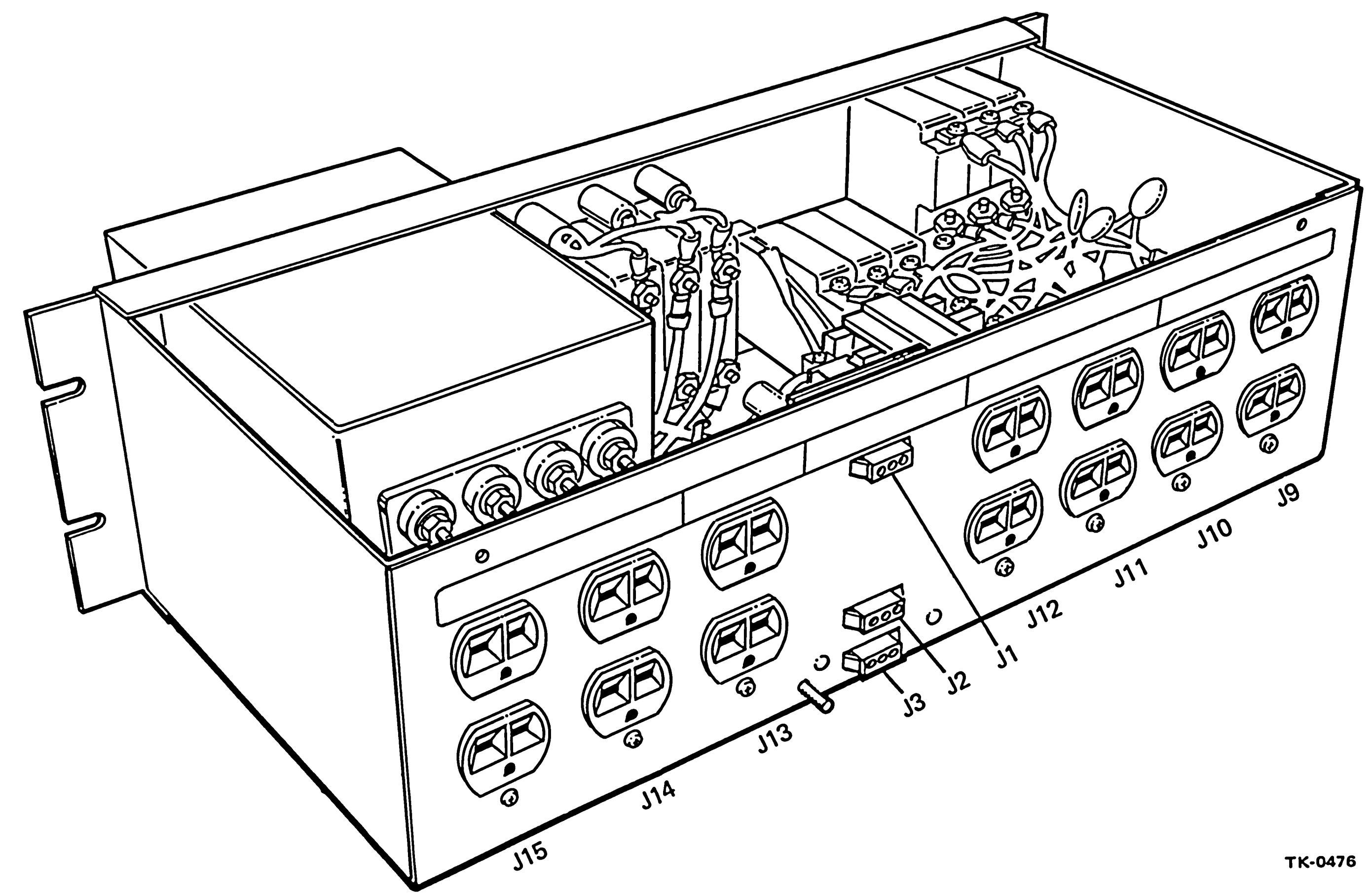


Figure 3-21 866E Power Controller (Rear View)

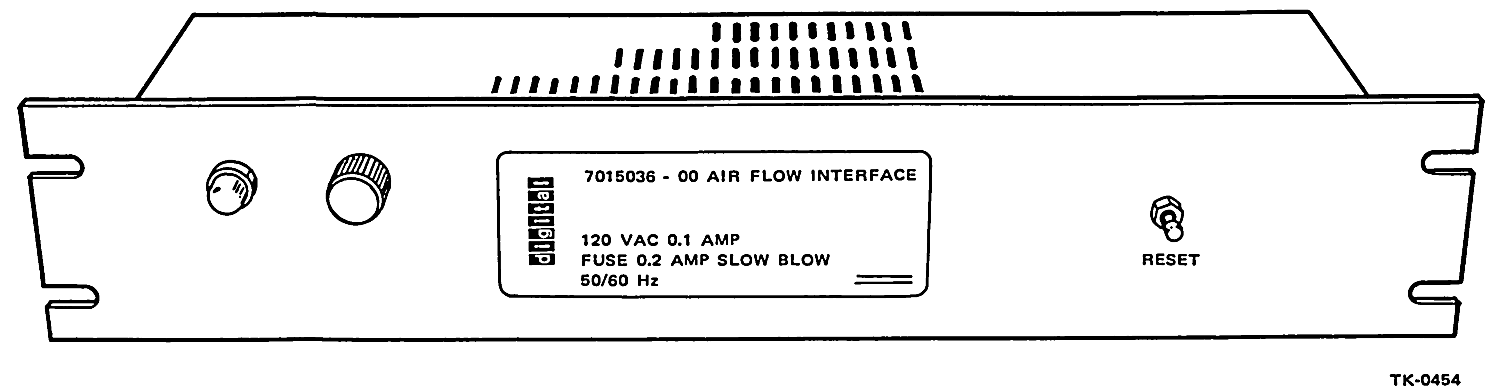


Figure 3-22 7015036-00 Air Flow Interface (+15 Vdc Power Supply)

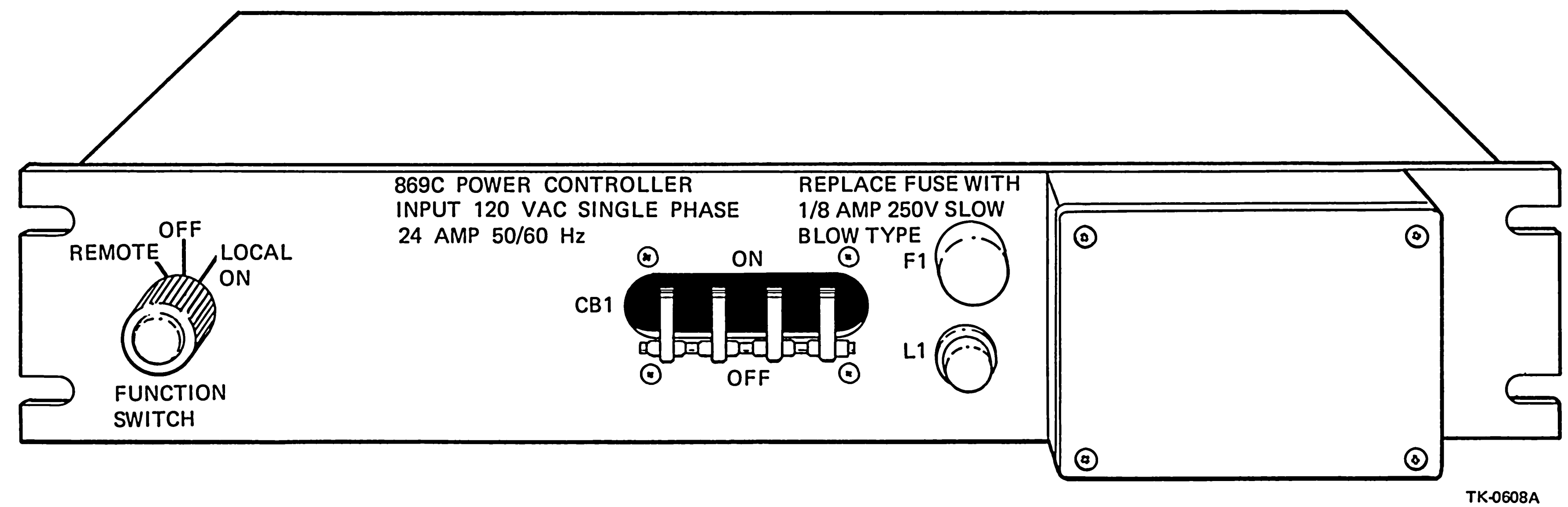


Figure 3-23 869C Power Controller (Front View)

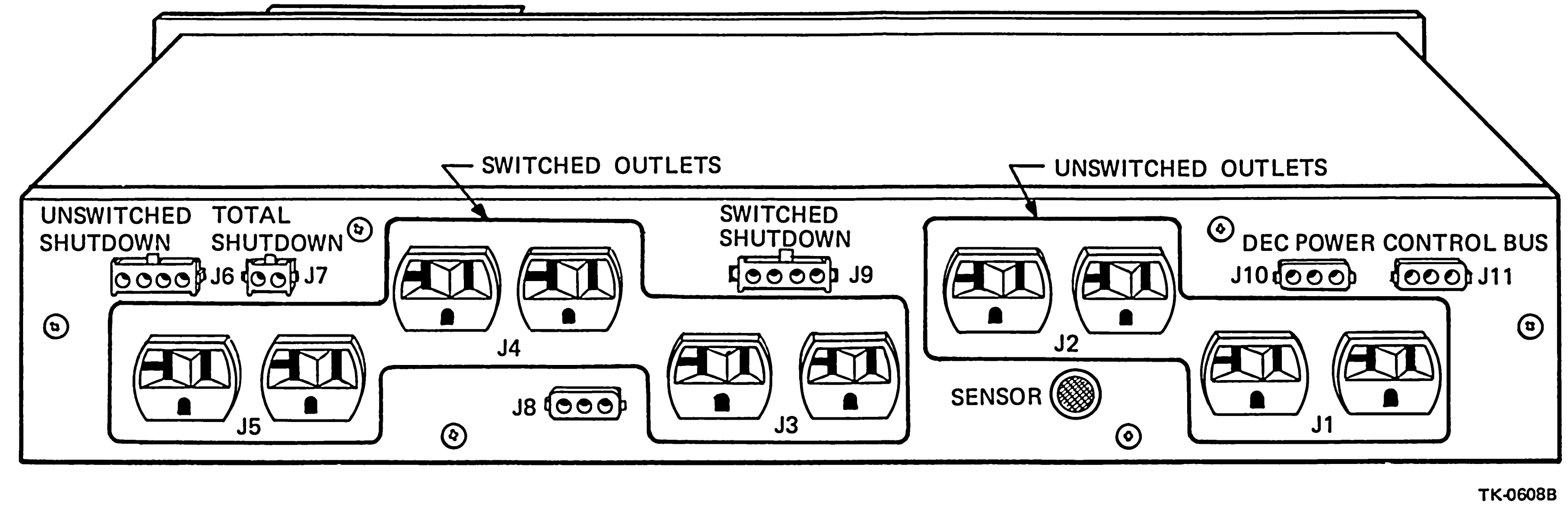


Figure 3-24 869C Power Controller (Rear View)

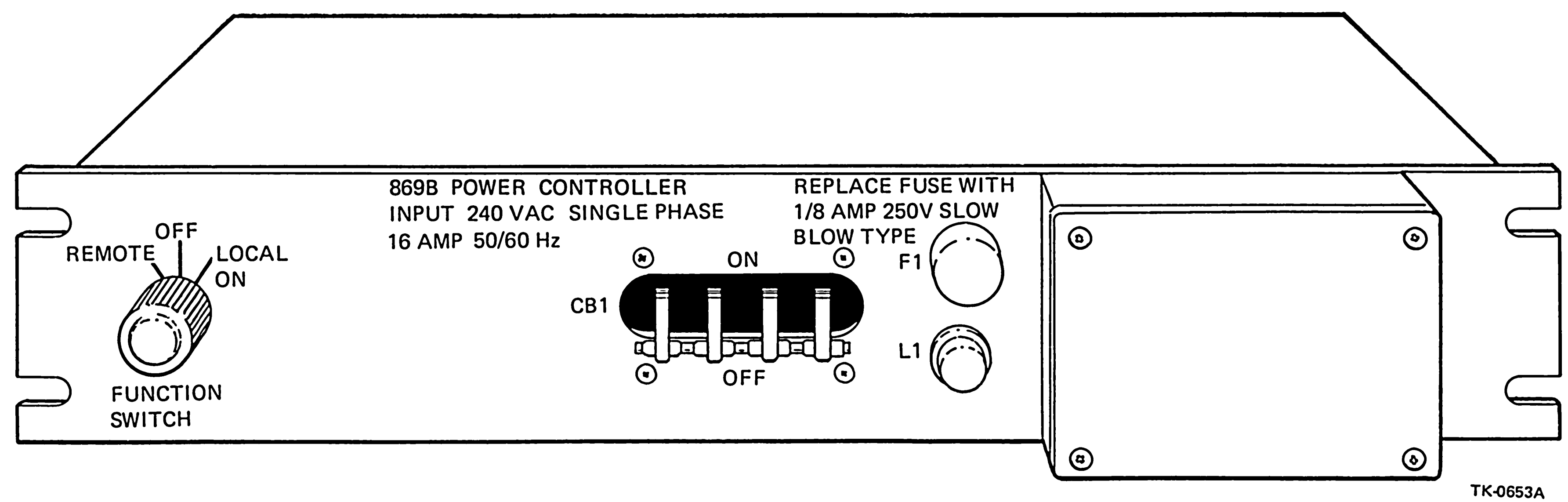


Figure 3-25 869B Power Controller (Front View)

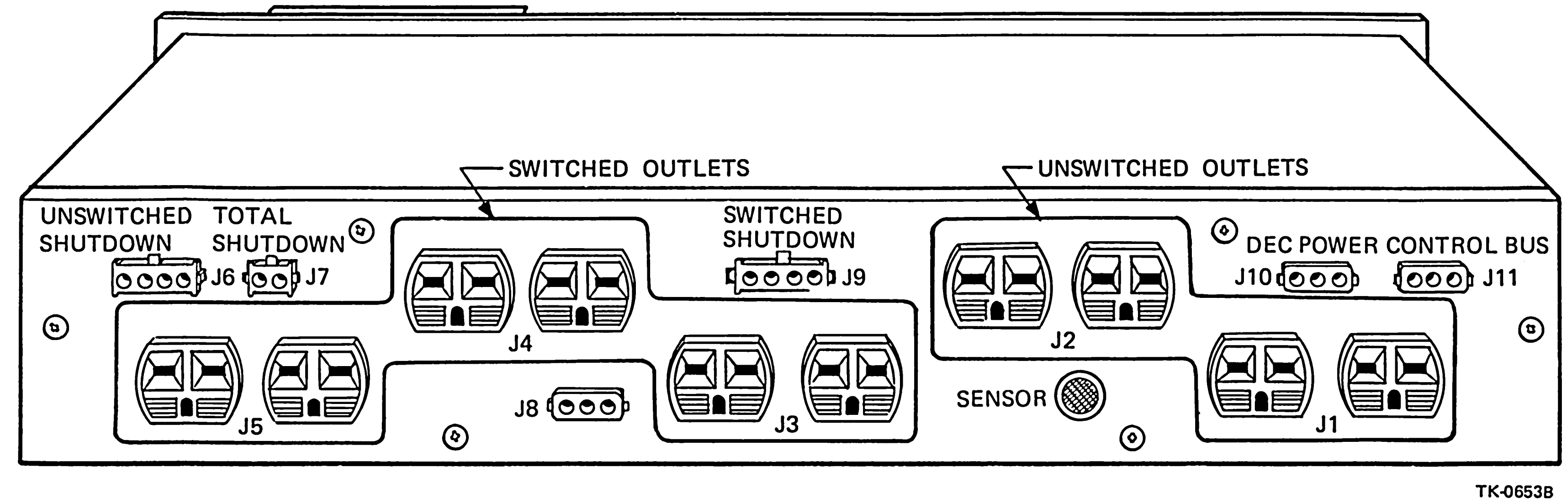


Figure 3-26 869B Power Controller (Rear View)

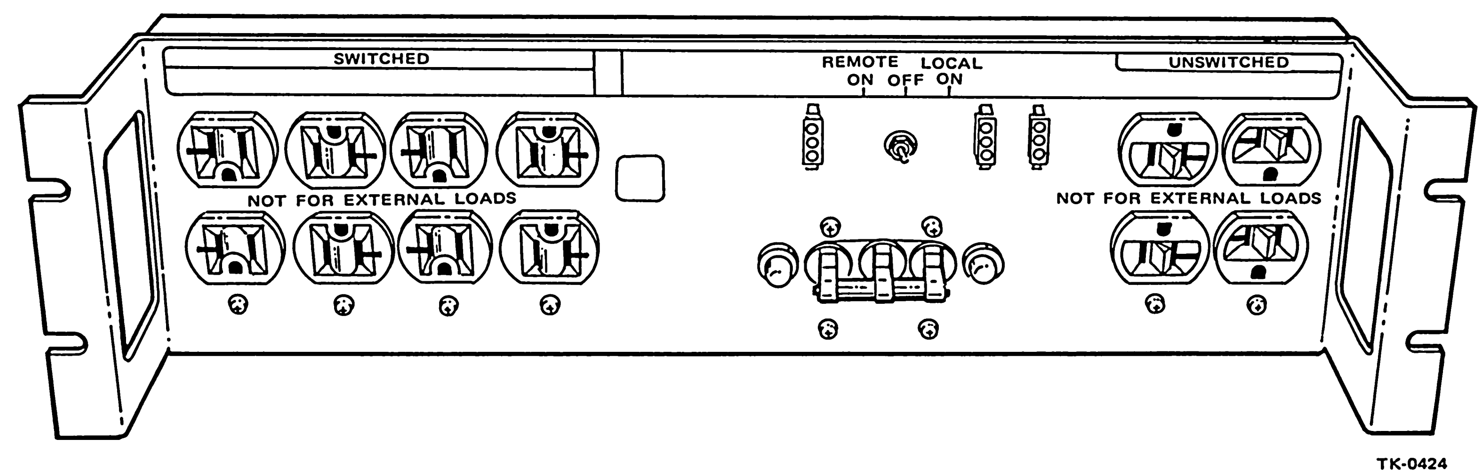


Figure 3-27 861C Power Controller (Front View)

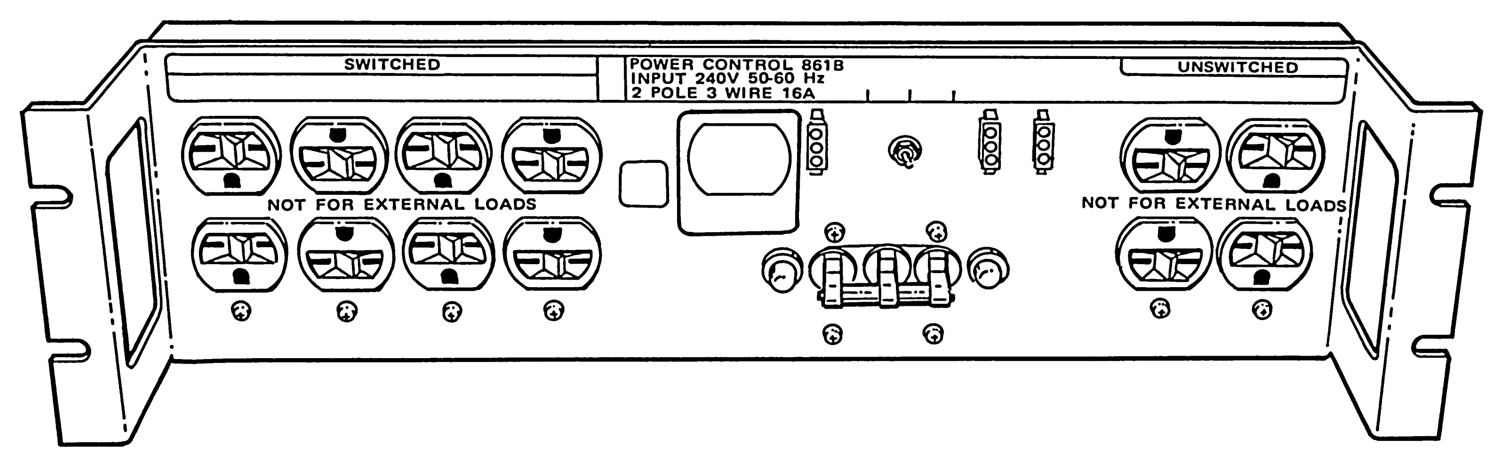


Figure 3-28 861B Power Controller (Front View)

Table 3-3 compares the 869D and 866D 120/208 Vac 3-phase controllers in terms of front-panel, back-panel, and interior features (Figures 3-14 through 3-21). The significant differences are as follows.

1. The 869D uses a main (3-phase) circuit breaker having inrush protection and a trip coil that permits shutdown of primary power to the controller's unswitched receptacles in response to a signal from the air flow sensor located above the memory power supply, or total shutdown in response to an overtemperature signal from a sensor in the controller, or from the overtemperature sensor in any of the power supplies. The 866D has neither a trip coil nor inrush protection, but both controllers can effect shutdown of receptacles on switched power.

2. The 869D has one more switched duplex outlet and one more unswitched duplex outlet than the 866D; specifically, the 869 has 3 switched outlets per phase, one unswitched and two switched.

3. The 869 provides a +15 Vdc output energizing up to 5 air flow sensors (only 3 are used in the VAX-11/780 main cabinets), thus eliminating the need for the +15 Vdc provided by the air flow interface (Figure 3-22) provided with each 866 controller.

4. The 869 provides an individual front-panel circuit breaker for each duplex receptacle, to enable manual disconnect of any device receiving power from this controller.

5. The pilot control board of the 869 replaces the reed relay and Triac combination (used for contactor control in the 866) with a solid-state switch. This board also includes delay circuitry which, if desired, powers up or down a second controller 1/2 second after receipt of a POWER REQUEST or EMERGENCY SHUTDOWN command via the power control bus.

A rear view comparison of the 869 and 866 power controllers (Figures 3-15 and 3-19) shows that both controllers have three (parallel-wired) connectors for the DEC power control bus; viz., J4, J5, and J6 on the 869 and J1, J2, and J3 on the 866. The 866 has no other control connectors.

The 869 controllers, because of their more extensive control flexibility, have four additional connectors (J7, J8, J9, and J10). These connectors are discussed briefly below (but not in the order named).

Switched Power Shutdown (Connector J8)
Closure of either air flow sensor for the switched fans (Figure 3-10, blowers 1 and 3), or any low (Table 2-2 under heading of "Input Signal Voltage Levels") from pin 2 to pin 1 of J8 on the back of the 869 power controller (Figure 3-15) will cause power to the switched outlets to be removed without energizing the emergency shutdown that occurs when an overtemperature signal appears on the DEC power bus. However, logic levels for a switched power shutdown via J8 must conform with those for the DEC power bus. Pin connections for J8 are as follows.

4	NC
3	+15 Vdc switched
2	Switched shutdown
1	Ground

Table 3-3 Comparison of 869D and 866D 3-Phase Power Controllers

FRONT PANEL	869 Controller	866 Controller
3-phase filter with cover and input studs	Yes	Yes
Phase lamps (3)	Yes	Yes
Transformer fuses (3)	Yes	No
LOCAL/OFF/REMOTE switch	Yes (rotary sel)	Yes (toggle)
Main circuit breaker control	Yes (4-pole)	Yes (4-pole)
Phase circuit breaker control	No	Yes (three 4-pole)
Output receptacle CBs (1 per duplex receptacle)	Yes (9)	No
REAR PANEL		
Output receptacles, duplex		
Switched	6	5
Unswitched	3	2
Connectors		
Power control bus	J4, J5, J6	J1, J2, J3
Delay out	J7	No
Switched shutdown	J8	No
Total shutdown	J9	No
Unswitched shutdown	J10	No
INTERIORS		
Main CB	Yes (with trip coil and inrush protection)	Yes (without trip coil or inrush protection)
Contactor	Yes	Yes
Pilot control board	Yes	Yes
Pilot control transformer	Yes (3-phase)	Yes (single phase)

Total Power Shutdown (Connectors J9 and J10)
Any low (Table 2-2) from pin 2 to pin 1 on J9 and J10 at the rear of 869 power controller will cause the main circuit breaker to trip, interrupting both the switched and unswitched power to output receptacles. Emergency shutdown on the DEC power control bus will be asserted. Logic levels must conform to those established for the DEC power bus. Pin connections for J9 and J10 are as follows.

J9

2	Total shutdown
1	Ground

J10

4	+15 Vdc unswitched
3	NC
2	Unswitched (total) shutdown
1	Ground

Air Flow Sensing (Connectors J8 and J10)
The controller is designed to interface with air flow sensor 12-14447 (TI-2SE). These barium-titanate SCR-switched sensors use the +15 Vdc supplied by connectors J8 and J10 (Figure 3-15). A maximum of five air flow sensors can be accommodated: three on switched +15 Vdc and two on unswitched +15 Vdc. Figure 3-32, the controller block diagram, shows the circuit relationships.

Cabinet Power-up Sequencing (Connector J7)
Connector J7 provides an output (at pin 1) for a 1/2 second delay in sequencing a second cabinet on, in response to a power-up request. If an 869 controller is used in the second cabinet, that 869 will provide another half second delay between the powering up of its cabinet and a third cabinet, etc.

Figures 3-29, 3-30, and 3-31 are matrices showing the effects of five input conditions at the controller on the three output conditions. Figure 3-29 shows these effects when the REMOTE/OFF/LOCAL (Mode Selector) switch on the front panel of the 869 is set to LOCAL MODE. Figures 3-30 and 3-31 show similar effects for the other two switch settings; i.e., OFF and REMOTE.

As shown, the five input variables are:

Main circuit breaker (CB1)
Power request (via J4, J5, or J6 – DEC power control bus)
Emergency shutdown (via J4, J5, or J6)
Switched shutdown (via J8)
Total shutdown (via J9) or unswitched shutdown (via J10).

The three output variables are:

Delayed power request
Switched power to outlets (J12, J13, J15, J16, J18, and J19)
Unswitched power to outlets (J11, J14, and J17).

Possible input states are identified in the legend. As is seen in Figures 3-29 and 3-30 the outputs for any given set of input conditions (e.g., condition 1) will be the same regardless of the ON or OFF state of the power request, as indicated by the column of Xs. In Figure 3-30, the Ys under heading of Delayed Power Request indicates that the OFF or ON state of this output is the same as that of the power request input for that condition. For example, in condition 4, if the power request state is ON and the other input conditions are as listed for this OFF mode of the selector switch, then the delayed power is ON and a 1/2 second delay will occur in the powering up of successive cabinets.

INPUT CONDITIONS						OUTPUT CONDITIONS		
MAIN CIRCUIT BREAKER	POWER REQUEST	EMERGENCY SHUTDOWN	SWITCHED SHUTDOWN	UNSWITCHED (TOTAL) SHUTDOWN		DELAYED POWER REQUEST	SWITCHED POWER TO OUTLETS	UNSWITCHED POWER TO OUTLETS
OFF	X	OFF	OFF	OFF	CONDITION 1	OFF	OFF	OFF
ON	X	OFF	OFF	OFF	CONDITION 2	Y	ON	ON
ON	X	ON	OFF	OFF	CONDITION 3	Y	OFF	ON
ON	X	OFF	ON	OFF	CONDITION 4	Y	OFF	ON
ON OFF	X X	OFF ON	OFF OFF	ON ON	CONDITION 5	OFF	OFF	OFF

LEGEND:

ON = TRUE
OFF = FALSE
X = EITHER ON OR OFF
Y = SAME ON OR OFF STATE AS X (POWER REQUEST) FOR THAT CONDITION

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Figure 3-29 869 Power Controller Input/Output Relationships – LOCAL ON Mode

INPUT CONDITIONS | OUTPUT CONDITIONS

MAIN CIRCUIT BREAKER	POWER REQUEST	EMERGENCY SHUTDOWN	SWITCHED SHUTDOWN	UNSWITCHED (TOTAL) SHUTDOWN		DELAYED POWER REQUEST	SWITCHED POWER TO OUTLETS	UNSWITCHED POWER TO OUTLETS
OFF	OFF	OFF	OFF	OFF	CONDITION 1	OFF	OFF	OFF
OFF	X	OFF	OFF	OFF	CONDITION 2	Y	OFF	OFF
ON	X	OFF	OFF	OFF	CONDITION 3	Y	OFF	ON
ON	X	ON	OFF	OFF	CONDITION 4	Y	OFF	ON
ON	X	OFF	ON	OFF	CONDITION 5	Y	OFF	ON
ON OFF	X X	OFF ON	OFF OFF	ON ON	CONDITION 6	OFF	OFF	OFF

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Figure 3-30 869 Power Controller Input/Output Relationships – OFF Mode

INPUT CONDITIONS						OUTPUT CONDITIONS		
MAIN CIRCUIT BREAKER	POWER REQUEST	EMERGENCY SHUTDOWN	SWITCHED SHUTDOWN	UNSWITCHED (TOTAL) SHUTDOWN		DELAYED POWER REQUEST	SWITCHED POWER TO OUTLETS	UNSWITCHED POWER TO OUTLETS
OFF	OFF	OFF	OFF	OFF	CONDITION 1	OFF	OFF	OFF
ON	OFF	OFF	OFF	OFF	CONDITION 2	OFF	OFF	ON
ON	ON	OFF	OFF	OFF	CONDITION 3	ON	ON	ON
ON	ON	ON	OFF	OFF	CONDITION 4	ON	OFF	ON
ON	ON	OFF	ON	OFF	CONDITION 5	ON	OFF	ON
ON OFF	ON ON	OFF ON	OFF OFF	ON ON	CONDITION 6	ON	OFF	OFF
ON	ON	ON	ON	OFF	CONDITION 7	ON	OFF	ON

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Figure 3-31 869 Power Controller Input/Output Relationships – REMOTE Mode

Note that in Figure 3-29, condition 5 has two discrete sets of input conditions that result in a single set of output conditions. A similar situation exists in condition 6 of Figures 3-30 and 3-31.

3.2.4 Controller Functional Descriptions

This section provides a detailed functional description of the 869 and 866 controllers used in VAX-11/780 systems. Table 3-1 lists the standard DEC controllers available for these systems.

3.2.4.1 869 Controllers – The 869 controllers used in VAX-11/780 systems are:

869D – 120/208 Vac, 3-phase
869E – 240/416 Vac, 3-phase
869C – 120 Vac, single phase
869B – 240 Vac, single phase.

869D Controller (3-Phase, 120/208 V)

Figure 3-32 is a block diagram of the 869D controller. The 120/208 Vac is customer provided from a 3-phase source to a DEC 12-12315 receptacle (NEMA L21-30R; Hubbell 2810). A 4.5 m (15 ft) 5-wire power cord with #10 conductors connects the five 10-32 ac input studs at the right front of the controller (Figure 3-14) to a DEC 12-12314 (NEMA L21-30P; Hubbell 2811) plug. Input cord color coding is: phase 1 – brown; phase 2 – black; phase 3 – black; neutral – blue; ground – green/yellow. The input terminals are mounted on and connect directly to the 3-phase filter, which provides low impedance paths to ground for high frequency components on the primary power lines. Filter outputs (3-phase wires and neutral) connect to the main circuit breaker, a 4-pole inrush-protected type fused at 30 A per pole and having two protective coils built in: a current coil that trips the circuit breaker to OFF if the inrush current exceeds 30 A/pole steady state or 450 A for 1/2 cycle, and a trip coil that provides automatic total shutdown of the system power when air flow and/or overtemperature sensors detect emergency conditions. Details of emergency shutdown implementation are covered in a later subsection of this system description.

Three front-panel indicator lamps (Figure 3-14) turn on as soon as the power plug is inserted into an energized receptacle, regardless of breaker ON/OFF status.

As seen in the block diagram, the 3-phase output of the circuit breaker (CB1) provides full 3-phase power to the following components of the controller:

Main contactor (K1)
3-phase stepdown transformer
Three duplex outlets (one per phase).

One leg of the 3-phase CB output is applied to a solid-state switch which, when closed by a command received via the DEC power control bus (parallel-wired three terminal connectors at the rear of the controller), passes the 120 Vac to the coil of the magnetic contactor K1 to cause its closure. A paralleled MOV (metallic oxide varistor) and 0.1 μfd capacitor on each leg of the three phase output from the contactor act to suppress the voltage spikes encountered when switching inductive loads (e.g., the blower motors) connected to the output receptacles energized by contactor closure. A total of 6 duplex receptacles, two on each leg of the 3-phase supply, are energized by the power-up command. Each duplex outlet receives its power through a single pole, 20 A circuit breaker that permits manual disconnect of any load at any time. These outlet breakers are not shown on the block diagram, and are not used in the 869E controller.

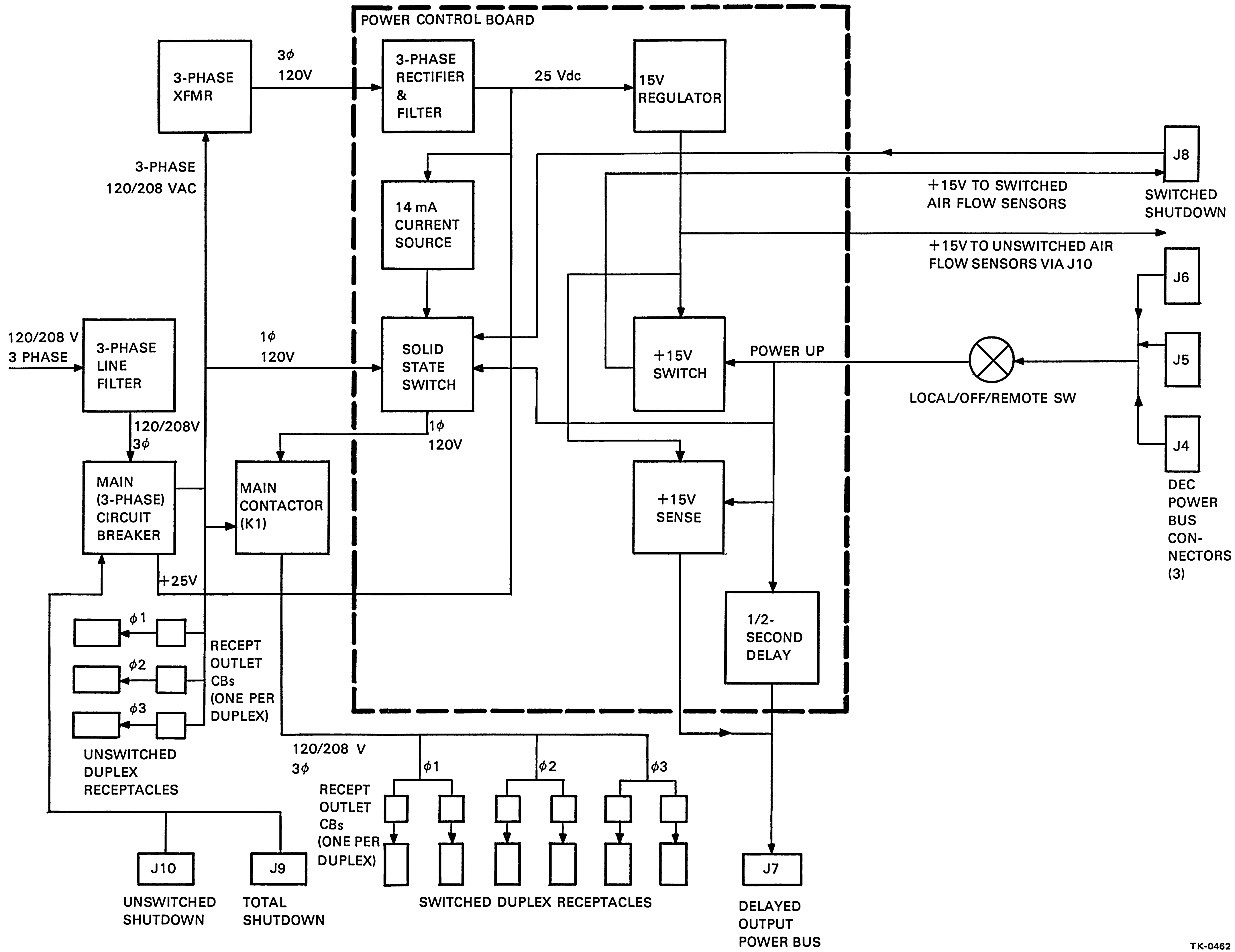


Figure 3-32 869D Power Controller Block Diagram

The 3-phase transformer (T1) provides a 3-phase output (3 windings) that is rectified and filtered to obtain a 25 Vdc output. This output is used to energize the trip coil of main circuit breaker CB1 upon closure of the controller's thermostat or receipt of an OFF (low) command from any of the system power supplies. The latter command originates with the closure of the overtemperature sensor located on the heat sink for the output rectifiers of the +5 Vdc output of each supply. The total shutdown command reaches the main CB via connector J9 (Figures 3-15 and 3-32). Total shutdown will also occur upon receipt of an unswitched shutdown command reaching the controller via its connector J10.

The 25 Vdc output of the 3-phase transformer also feeds a 14 mA current source and a 15 V regulator. The current source meets the specific requirements of the solid-state relay input circuit (a light-emitting diode in series with a resistor). Light emission is cut off and the solid-state switch opens the 120 Vac control signal to the main contactor (K1) when a LOW (ground) signal is received from either of the air flow sensors whose associated blower (No. 1 or No. 2) is connected to switched phase 3 (Figure 3-12). This signal reaches the solid-state switch via controller connector J8 (switched shutdown). When the contactor is deenergized, all power to devices connected to switched phases is killed.

The 15 Vdc regulator output is fed directly to the unswitched air flow sensor (AFS#2) located above the memory power supply (P.S. #3 in Figure 3-11). This output is also fed to a 15 V switch consisting of two transistors. After a power-up command has energized the system, this switch passes the +15 Vdc to the two air flow sensors located above blowers 1 and 3, which operate off switched phase 3 (Figure 3-12).

Each air flow sensor (a pencil-shaped device approximately 4 inches long) is bracket-mounted in a fore-and-aft position in the narrow space between the tops of the power supplies and the bottoms of the card cages. Each sensor (Figure 3-33) consists of a barium-titanate sensing element, a control circuit, and an SCR.

If the air flow sensor for unswitched power responds to a combined temperature/air velocity condition exceeding design limits, its control circuit triggers the SCR to generate a ground return signal that energizes the circuit breaker's trip coil via a line to pin 2 of controller connector J10.

If either switched-power air flow sensor is similarly energized, the returned ground signal deenergizes the solid-state switch, which in turn opens the contactor to remove power to all devices on the two switched phases (2 and 3).

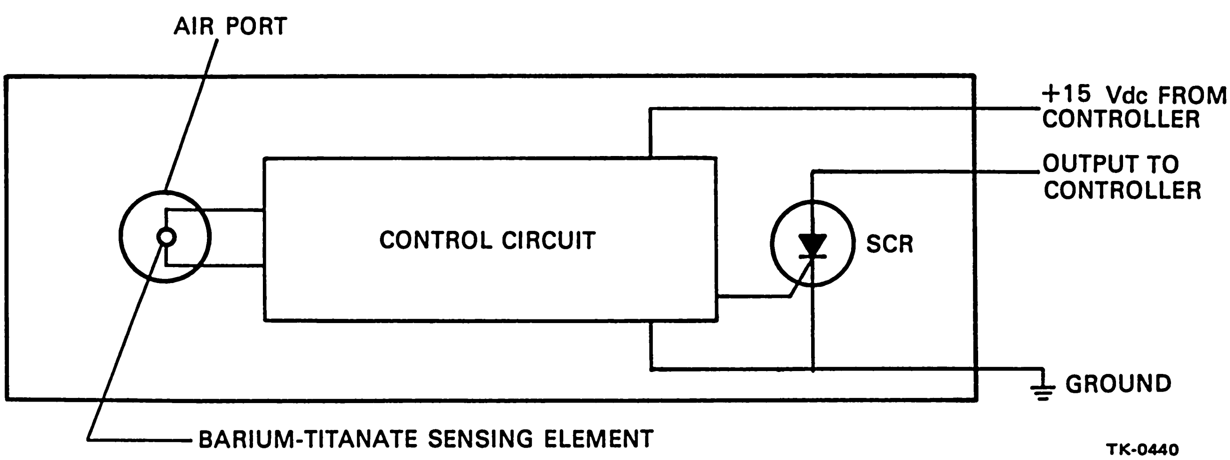


Figure 3-33 Simplified Diagram of Air Flow Sensor

The purpose of the 15 V sense circuit is to detect the loss of +15 Vdc when the controller receives a total shutdown signal via connector J9. Upon detection, this circuit initiates a power request signal on the power control bus after a 1/2 second delay so that other cabinets can continue operation despite main cabinet shutdown. A normally closed relay in the +15 V sense circuit effects this operation.

Figure 3-34 is a schematic of the 869D 3-phase power controller.

869E Controller (3-Phase, 240/416 V)
The 869E controller differs from the 869D controller in only two major points:

1. Input voltage
2. The elimination of the individual circuit breakers for each duplex outlet.

As seen from Table 2-2, 869E input voltage is 240/416 rather than 120/208. 869E input current capability and breaker size are correspondingly reduced (12 A/phase rather than 24 A/phase, and 15 A/pole rather than 30 A/pole, respectively).

The front panel drawings (Figures 3-14 and 3-16) show the physical similarity of the two controllers (with the exception of the individual circuit breakers referred to above). The corresponding rear views (Figures 3-15 and 3-17) are identical; i.e., the connectors (J4 through J10) are the same and in the same locations. The duplex outlets are identically located and arranged in the same switched/unswitched combinations.

The pilot control board is identical in both controllers. The input transformer for this board is a 240 V 3-phase input type delivering the same voltages to the board as its 120 V equivalent in the 869D. The power contactor is also a 240 V version, as is the solid-state switch.

At the duplex outlets, the 869E is rated at 12 A per outlet as compared with 16 A per outlet for the 869D. Output voltage is 240 Vac rather than 120 Vac.

As seen from Table 2-2, the two controllers have the same mechanical and environmental characteristics, including rack mounting dimension 48.26 cm (19 in).

With one exception, the schematic of the 869D controller is the same as that for the 869E; i.e., the E model does not have the individual outlet CBs that are provided in the D model. Accordingly, the 869E schematic is not included in this manual, even though provided in the print set.

869 Single-Phase Controllers (869C, 120 V; 869B, 240 V)
The technical description of the 869 3-phase controllers is also applicable to the 869 single-phase controllers and is therefore not repeated here. However, phase and voltage differences entail some component variations; these are summarized in Table 3-4.

With these differences and two others mentioned below, the block diagram of Figure 3-32 and the schematic of Figure 3-34 apply to the 869C and 869B devices.

All four controllers in the present 869 family have the following basic similarities.

1. Use of the same (5413016) pilot control board
2. Provision for the same control signal inputs.

With respect to item 2, it should be noted that the Mate-N-Lok connectors for the single-phase 869s have different J-numbers from the corresponding connectors of the 3-phase controllers; note also that there are only two power control bus connectors (J10 and J11) in the single phase controllers as compared with the three (J4, J5, and J6) provided in the 3-phase controllers.

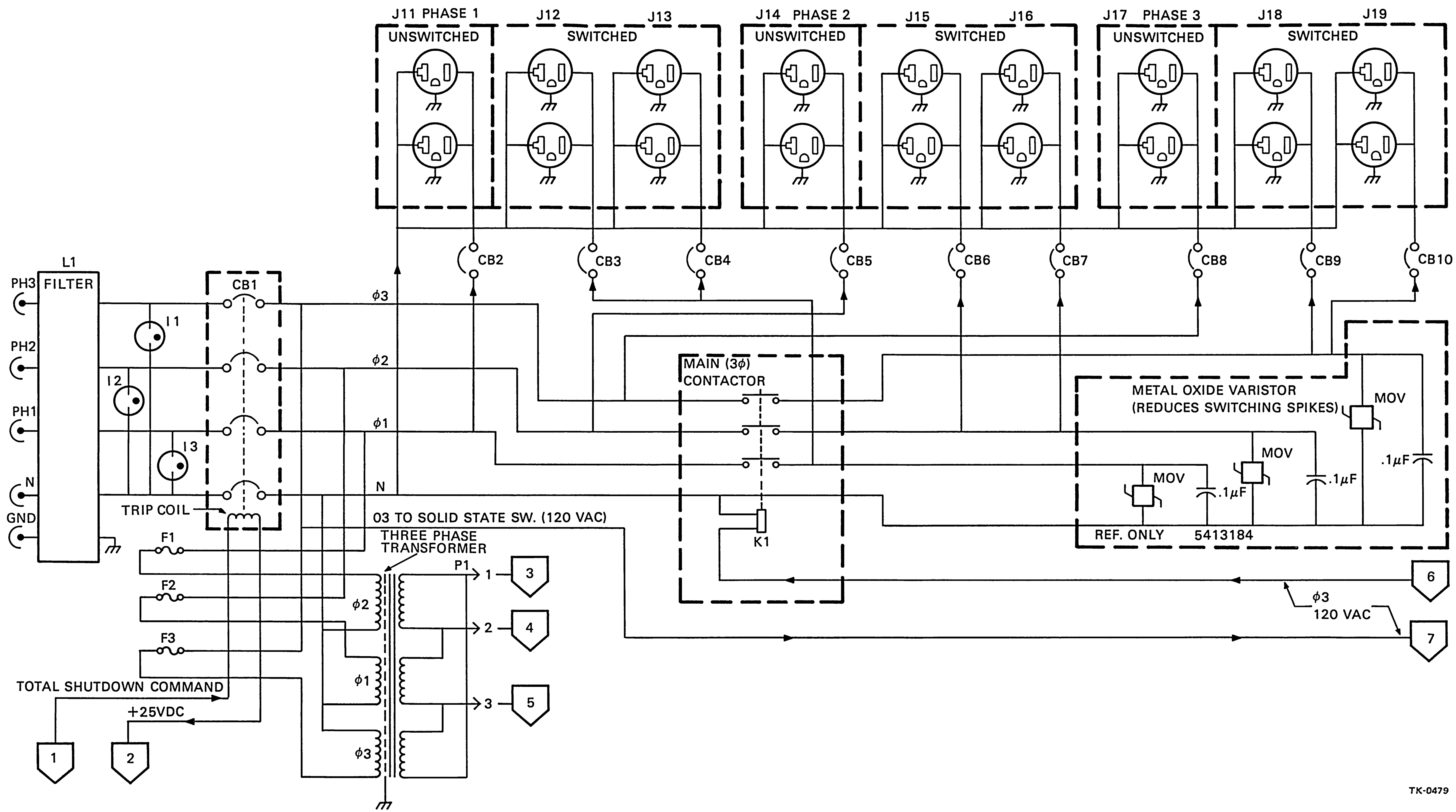


Figure 3-34 Schematic of 869D 3-Phase Power Controller (Sheet 1 of 2)

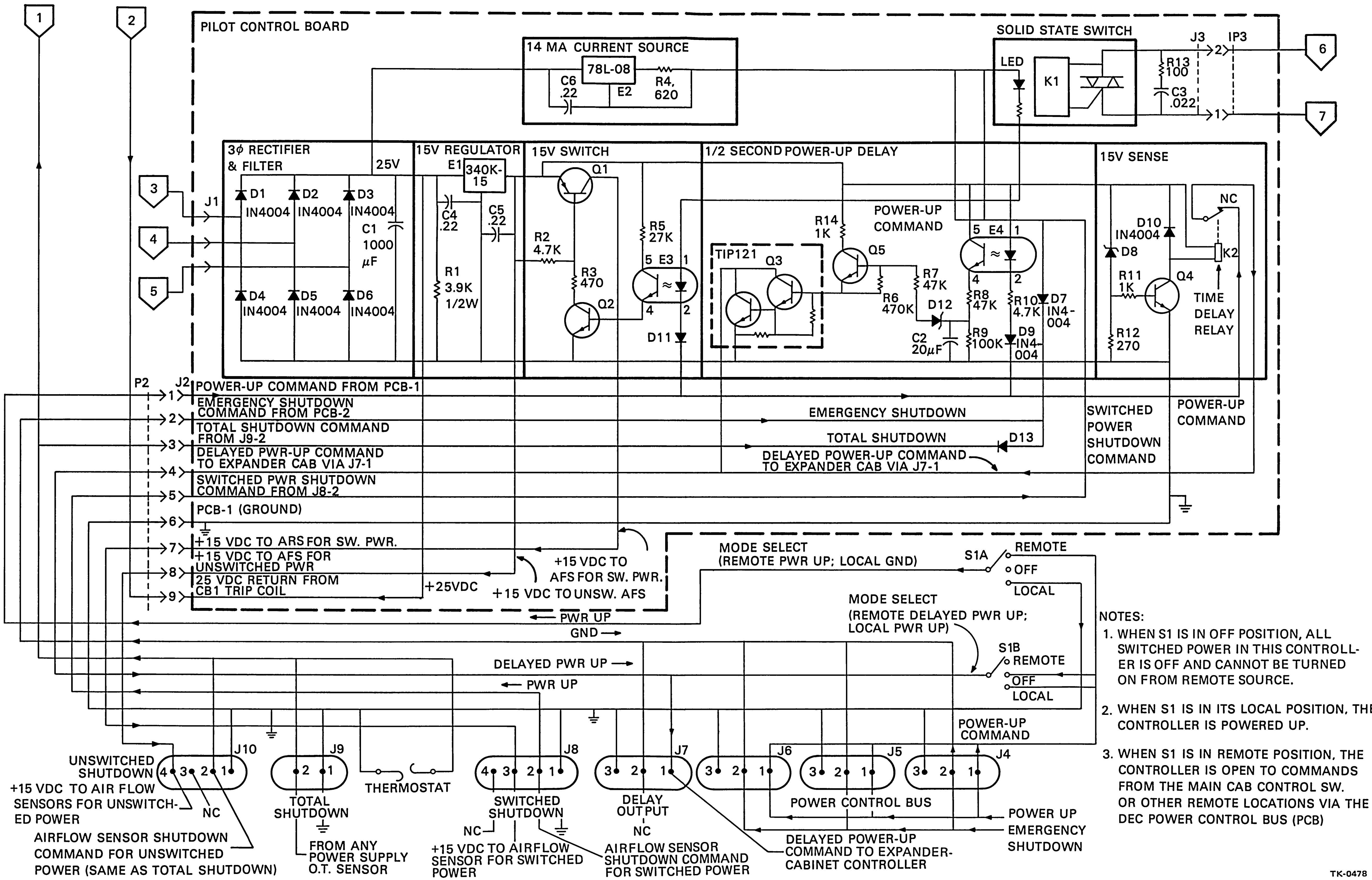


Figure 3-34 Schematic of 869D 3-Phase Power Controler (Sheet 2 of 2)

Table 3-4 Comparison of Major Component Differences in 869 Power Controller Family

Item	869D (120/208 V, 30)	869E (240/416 V, 30)	869C (120 V, 10)	869B (240 V, 10)
FRONT PANEL				
Line filter	3-phase	3-phase	1-phase	1-phase
Phase lamps	3 (120 V)	3 (120 V)	1 (120 V)	1 (120 V)
Transformer fuses	3 (0.12 A)	3 (0.12 A)	1 (0.2 A)	1 (0.2 A)
LOCAL/OFF/REMOTE Switch	1 (rotary sel.)	1 (rotary sel.)	1 (rotary sel.)	1 (rotary sel.)
Main circuit breaker control	4 pole	4 pole	4 pole	4 pole
Phase circuit breaker control	No	No	No	No
Output circuit breakers	Yes (9)	No	No	No
REAR PANEL				
Output duplex receptacles				
Switched	6	6	3	3
Unswitched	3	3	2	2
Connectors				
Power control bus	J4, J5, J6	J4, J5, J6	J10, J11	J10, J11
Delay out	J7	J7	J8	J8
Switched shutdown	J8	J8	J9	J9
Unswitched shutdown	J10	J10	J6	J6
Total shutdown	J9	J9	J7	J7
INTERIOR				
Main circuit breaker				
A/pole	30–30–30–0*	15–15–15–0*	20–20–30	15–15–20
Inrush protection	Yes	Yes	Yes	Yes
Trip coil	Yes	Yes	Yes	Yes
Contactor				
Voltage	120	240	120	240
No. of poles	3	3	2	2
Pilot control board	5413016	5413016	5413016	5413016
Pilot control xfmr	120 V, 30	240 V, 30	120 V, 10	240 V, 10

*This segment of the main CB is used for overcurrent switch.

Figures 3-23 and 3-24 show front and rear views of the 869C; Figures 3-25 and 3-26 show front and rear views of the 869B. With the exception of nameplate differences, the front views of both single phase 869s are identical; the rear views of the two controllers are identical with the exception of duplex receptacle polarization (the neutral and the "hot leg" terminals are horizontally oriented for 240 V output receptacles and vertically polarized for 120 V receptacles).

For 869C and 869B controller specifications, refer to Table 2-5.

3.2.4.2 866 Controllers – The 866D and 866E 3-phase controllers will be used in the VAX-11/780 main cabinets and SBI (system expansion) cabinets in systems delivered prior to June 1978. The 866D is a 90–132 Vac, 47–63 Hz, 3-phase power controller. The 866E is its 180–264 Vac, 47–63 Hz equivalent. The pilot control boards for the two controller types are identical and are discussed in the following subsection on the 866D only. Figure 3-9 is a simplified block diagram applicable to both units.

866D Controller (3-Phase, 120/208 V)
Figure 3-35 is a schematic of the 866D. For front and rear panel controls, indicators, outlets, etc., refer to Figures 3-18 and 3-19. For specifications details, refer to Table 2-4.

As shown in the simplified block diagram, the 866D and 866E are conceptually similar to the 869. However, the 866 does not have a magnetic circuit breaker that can be tripped for a total shutdown. However, the control of the switched outlets via the DEC power control bus and contactor is the same. With the main circuit breaker manually set to ON, power is always available at the unswitched outlets until the breaker is manually set to OFF. The three indicator lamps (one for each phase) light whenever the plug of the input power cord is inserted in a live receptacle.

Power is applied to the terminal block (mounted on the power line filter) via a 4.5 m (15 ft) line cord or, alternatively, can be hardwired to this block. The 3-phase filter provides low impedance paths to ground for high frequency line components. If 120 Vac is present between phase 1 and neutral, lamp I1 lights. Similarly, if 120 Vac is present between phase 2 and neutral, I2 lights. I3 indicates ON status of phase 3 when 120 Vac is present between phase 3 and neutral.

All 3-phase lines are connected to 30 A elements in circuit breaker CB1. All loads connected to the power controller (both switched and unswitched) are controlled by 20 A circuit breakers (CB2, 3, and 4) for each outlet.

The coil associated with contactor K1 is energized by 120 Vac if a relay (K1) on the pilot control board is closed. If the current through any outlet exceeds 20 A, the respective circuit breaker trips, removing power from the loads.

When contactor K1 is closed, 120 Vac is applied across the switched outlets. The 0.1 μF capacitors (C1 and C2) and the three MOVs (R2, R3, and R4) connected across the lines at the contactor reduce the amplitude when switching inductive loads, thereby preventing interference with nearby electronic data processing equipment.

The pilot control board contains the circuitry which allows remote turn-on and emergency turn-off of the switched power outlets in both 866 power control versions. These functions are accomplished by controlling the voltage applied to the coil of relay K1 in the 866 power controller.

Basically the circuit consists of a triac operated by reed relay K1. Controlling this relay is a transistor network which is in turn controlled by inputs from connectors J2, J3, J4, J5, and J7. J2, J3, and J4 are 3-pin connectors which carry signals from the DEC power control bus. Pin 1 is the enable (power request) line from the power control bus. Pin 2 is the disable (emergency shutdown) line from the signal bus. Pin 3 is the common line. J7 is a 3-pin connector which carries signals from the LOCAL/OFF/REMOTE switch on the front panel of the 866. Two additional lines (from the thermal switch) are connected to pins 1 and 2 of J5.

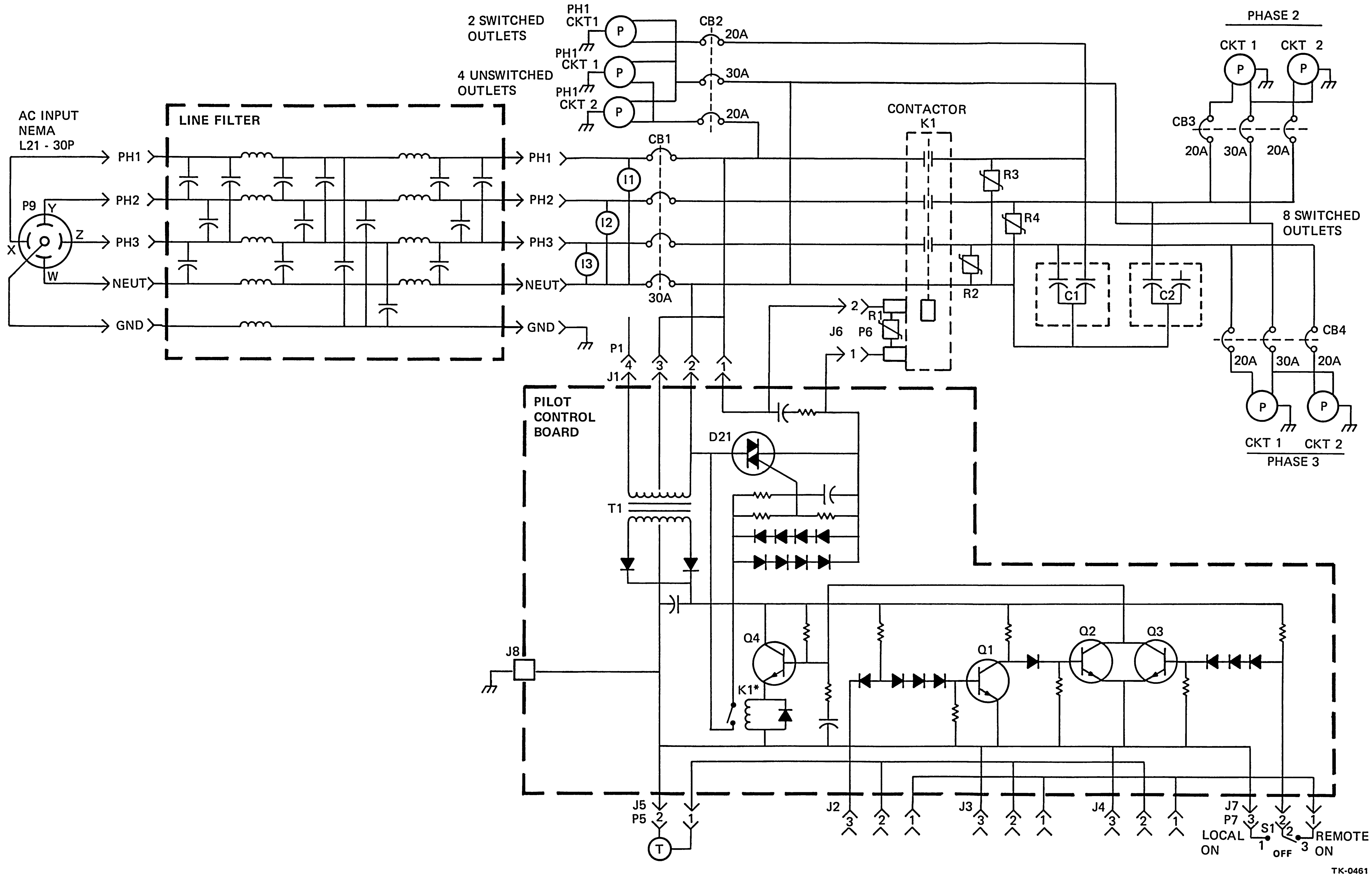


Figure 3-35 866D Power Controller Schematic

If the LOCAL/OFF/REMOTE switch is in the REMOTE position and pins 3 and 1 (on J2, J3, or J4) are connected through the transistor network, reed relay K1 turns on. There is a short turn-on delay caused by an RC network in the base circuit of Q4, the transistor driving K1. K1 in turn fires the triac, SCR D21. This causes an energizing potential to be applied, through connector J6, across the coil associated with contactor K1 in the power controller, thereby energizing the switched outlets. When pins 2 and 3 of J2, J3, or J4 are connected (emergency shutdown is true) K1 is turned off, turning off SCR D21. The resultant current through the coil is less than that required for holding the main relay closed. Therefore, energizing potential is not present at contactor K1 and power is removed from switched outlets.

Closing T (the thermal switch connecting pins 1 and 2 of J5) performs the same function as emergency shutdown (i.e., connects pins 2 and 3 together). This switch is exposed to the ambient air surrounding the power controller. Temperatures above 71° C (160° F) close the switch disabling the switched outlets. The switch resets automatically when the temperature drops below 49° C (120° F).

Placing the LOCAL/OFF/REMOTE switch in the LOCAL position provides a connection to energize relay K1 regardless of the state of the power request line on the signal bus. This switch position is normally used for maintenance purposes; operations on the pilot control board are exactly the same for situations where a connection is provided between pins 3 and 1 of the signal bus connector due to closing of a circuit in an external device. A connection between pins 2 and 3 disables the switched outlets, regardless of the position of the LOCAL/OFF/REMOTE switch.

866E Controller (3-Phase, 240/416 V)
Figure 3-36 is the schematic of the 866E. The operation of this controller as well as the number of switched and unswitched outlets are identical to those of the 866D. Input voltage for this controller is 240/416, 3-phase, wye connected. The operation of the pilot control board was described in the preceding section on the 866D and is not repeated here.

3.2.4.3 861 Controllers – The model, frequency, and phase options for the single-phase 861B and 861C versions of this controller were listed in Table 3-1. Used in the Unibus Expansion Cabinet, this controller is covered in detail in the *861-A, B, C, D, E, F Power Controller Maintenance Manual* (EK-861AB-MM-002). This manual is included in the VAX-11/780 documentation packages.

3.3 DC POWER DISTRIBUTION AND GENERATION

Figure 3-37 is a simplified diagram of the dc power distribution in the VAX-11/780 system. All dc power is generated by the five H7100 power supplies previously referred to and discussed in more detail in later sections of this manual.

3.3.1 Power Distribution

As seen in Figure 3-37, the basic system is serviced by three of the five power supplies; i.e., those designated as No. 2, No. 3 and No. 4 in the figure. Power supply No. 2 provides the 4 modules of the DW780 Unibus Adapter (UBA) and some of the modules of the KA780/KU780 CPU with +5.1 Vdc at 30 A; it provides -5.2 V at 10 A for the entire modular load shown in the figure by means of the basic H7100 and its H7101 regulator. Power supply No. 3 provides +5.1 Vdc at 70 A to some of the modules comprising the CPU and its writable control store (WCS), i.e., the KA780/KU780, using the basic H7100 alone.

Power supply no. 4 provides the five modules of the MS780A memory with +5.1 V at 50 A, +12 V at 10 A, +5 V at 20 A, and -5 V at 0.2 A. The +5 Vdc required by the time-of-day clock is provided by the H7111 battery power supply (Paragraph 3.4.2.2). The H7112 is an optional battery backup supply for P.S. No. 4, the memory supply.

Power supply No. 1 provides the 5 modules of the optional FPA with +5.1 V at 40 A, and power supply No. 5 provides the two RH780 MBAs with +5 V at 20 A each.

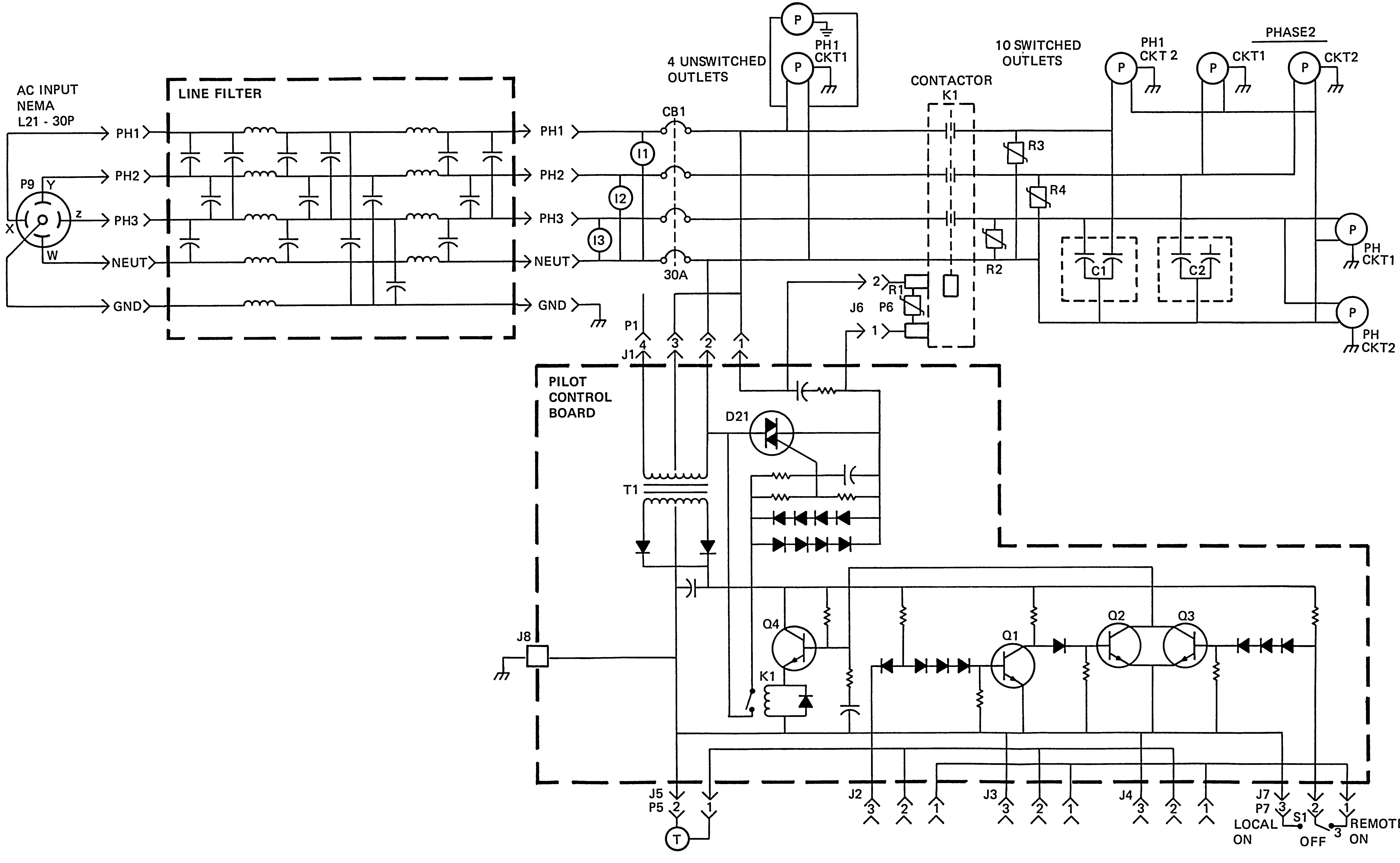


Figure 3-36 866E Power Controller Schematic

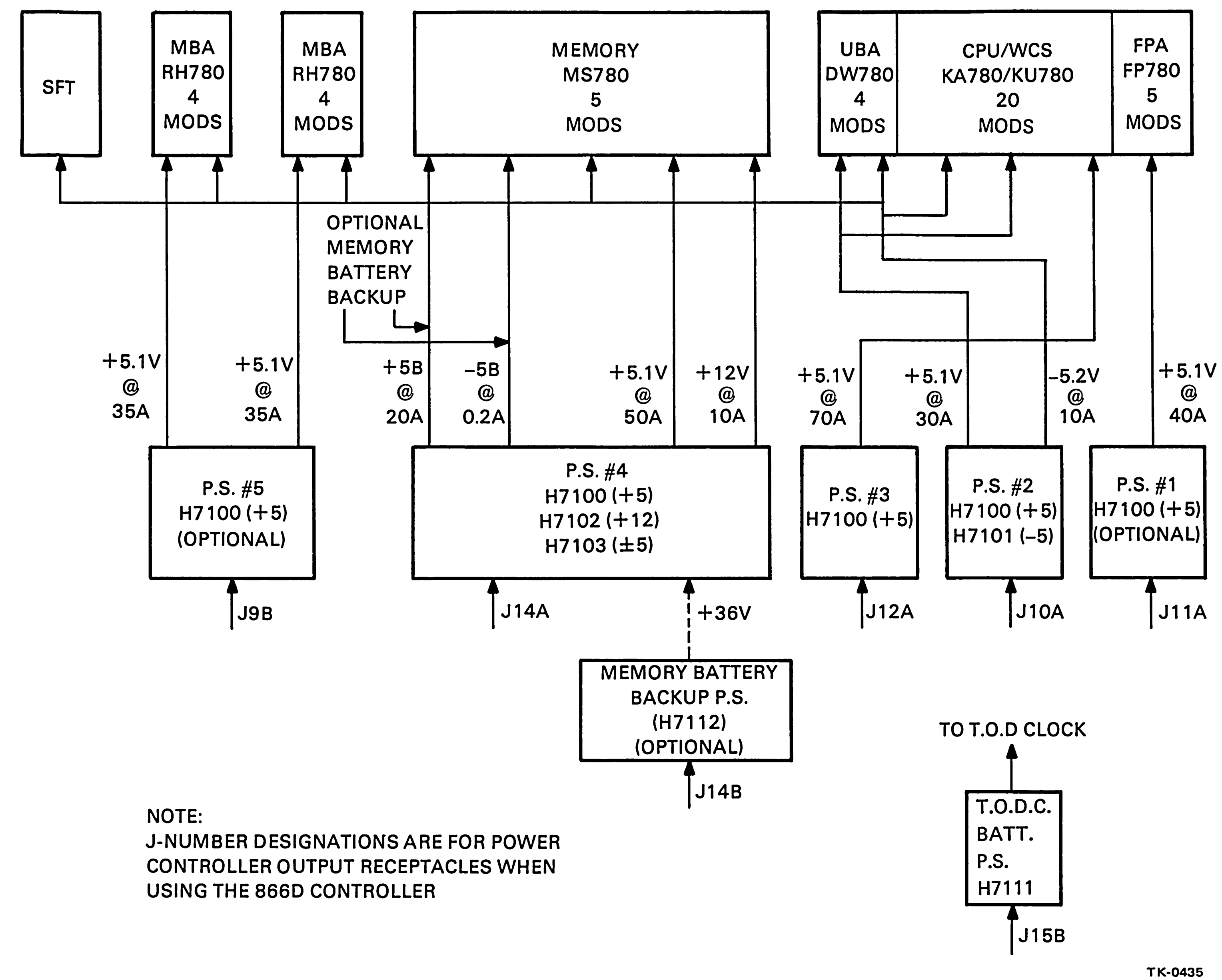


Figure 3-37 Main Cabinet DC Power Distribution

The basic dc power supply for the VAX-11/780 is the H7100, which delivers +5 Vdc at 100 A. Plug-in switching regulators permit this supply to be configured for specific additional dc loads (Paragraph 3.3 DC Power Distribution and Generation). The total load on any one supply never exceeds 500 W; i.e., if a supply delivers voltages other than +5 Vdc, the +5 Vdc amperage available is reduced by these other demands. Five status indicators on the front of each supply provide general indications as to the location of any malfunctions; a sixth indicator is lit whenever power supply operation is normal (Paragraph 3.4.3).

The H7100 power supply:

1. Delivers the regulated dc output voltages required for central processor operation.

2. Senses several power supply malfunctions and provides visual (front panel) indications of same.

3. Provides an overtemperature sense signal to the power controller.

4. Incorporates current limiting and overvoltage protection.

5. Generates AC LO and DC LO signals for use by the CPU in power-fail sequencing.

6. In conjunction with the H7112 battery backup power supply (an option), provides memory refresh voltages during power outages of limited duration.

3.3.2 Power Generation – H7100 DC Power Supply

3.3.2.1 General – The VAX-11/780 power supply is the H7100, a 500 W unit that can supply several dc output voltages in addition to its basic +5 Vdc, 100 A output. In concept, the supply is an ac-to-dc converter incorporating switching regulation of the dc outputs. The supply offers a choice of three plug-in regulators. Either of two ac input adapters can be used, thus permitting operation from 120 or 240 Vac at 50 or 60 Hz line frequency. Also incorporated in each adapter are protection circuits for the power supply and its loads, and a status display. The VAX 11/780 main cabinet provides space for up to six H7100 supplies. The supply weighs 15.9 kg (35 lb) and is 178 mm (7 in) wide, 279 mm (11 in) high, and 406 mm (16 in) in depth.

The basic concept employed in a switching regulator (Figure 3-38) is to vary the duty cycle of the pulsed dc applied to a power transformer whose rectified and filtered output provides a relatively low-voltage, high-current source for the computer's logic and control circuits. The single-line diagram of Figure 3-39 shows the functional elements of the H7100. The +300 Vdc output of the raw dc section is applied to a 20 kHz dc-to-ac inverter whose duty cycle is varied as a function of sensed output voltage variations relative to an accurate +5.1 Vdc reference signal. The inverter provides isolation between the line and the load. The variable duty cycle ac is stepped down through a transformer, rectified and filtered. Duty cycle is controlled by a pulsed transistor switch and a base-driver transformer whose primary winding is energized by the output of a 20 kHz pulse-width modulator.

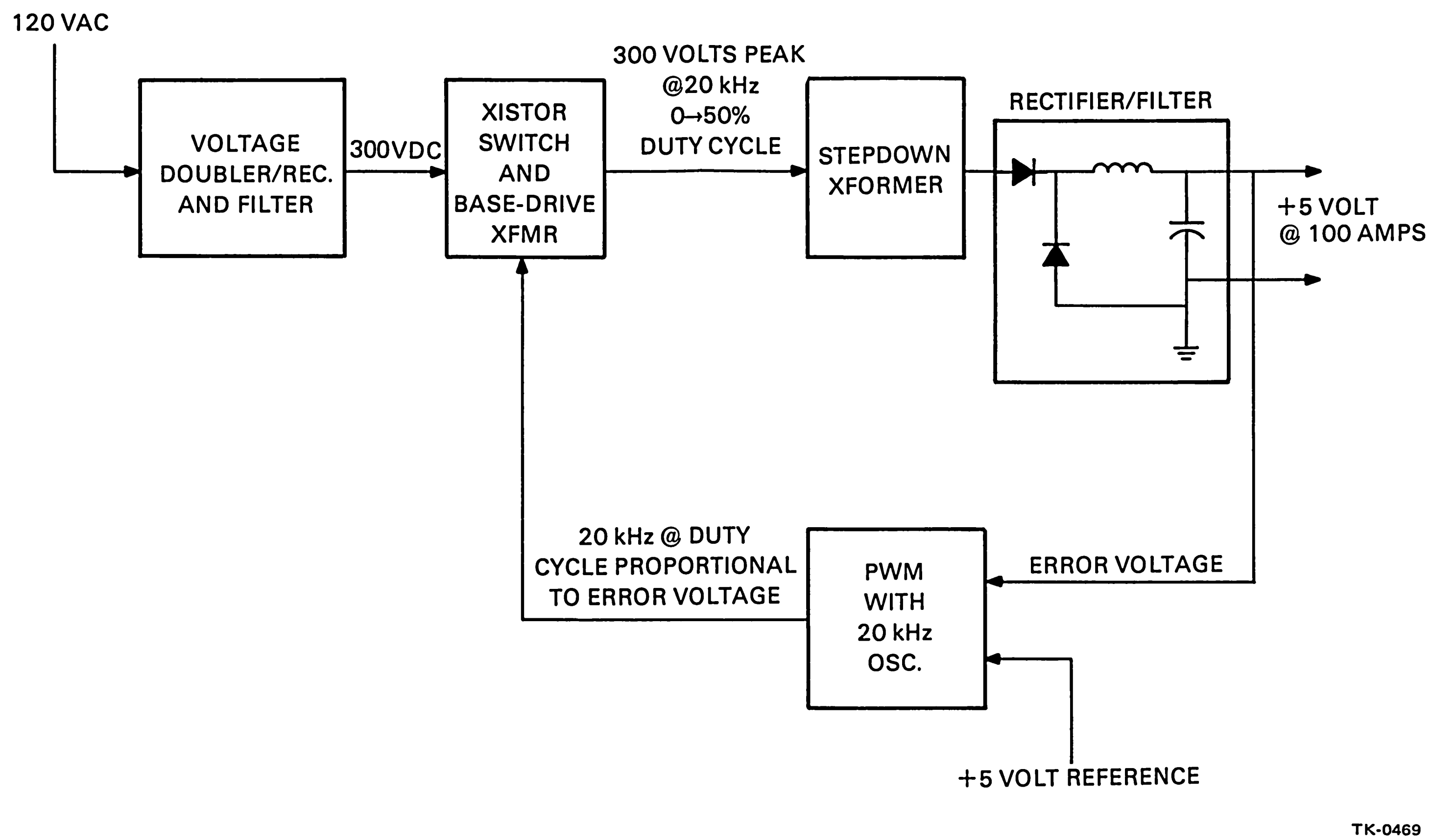


Figure 3-38 Basic Concept of a Switching Regulator

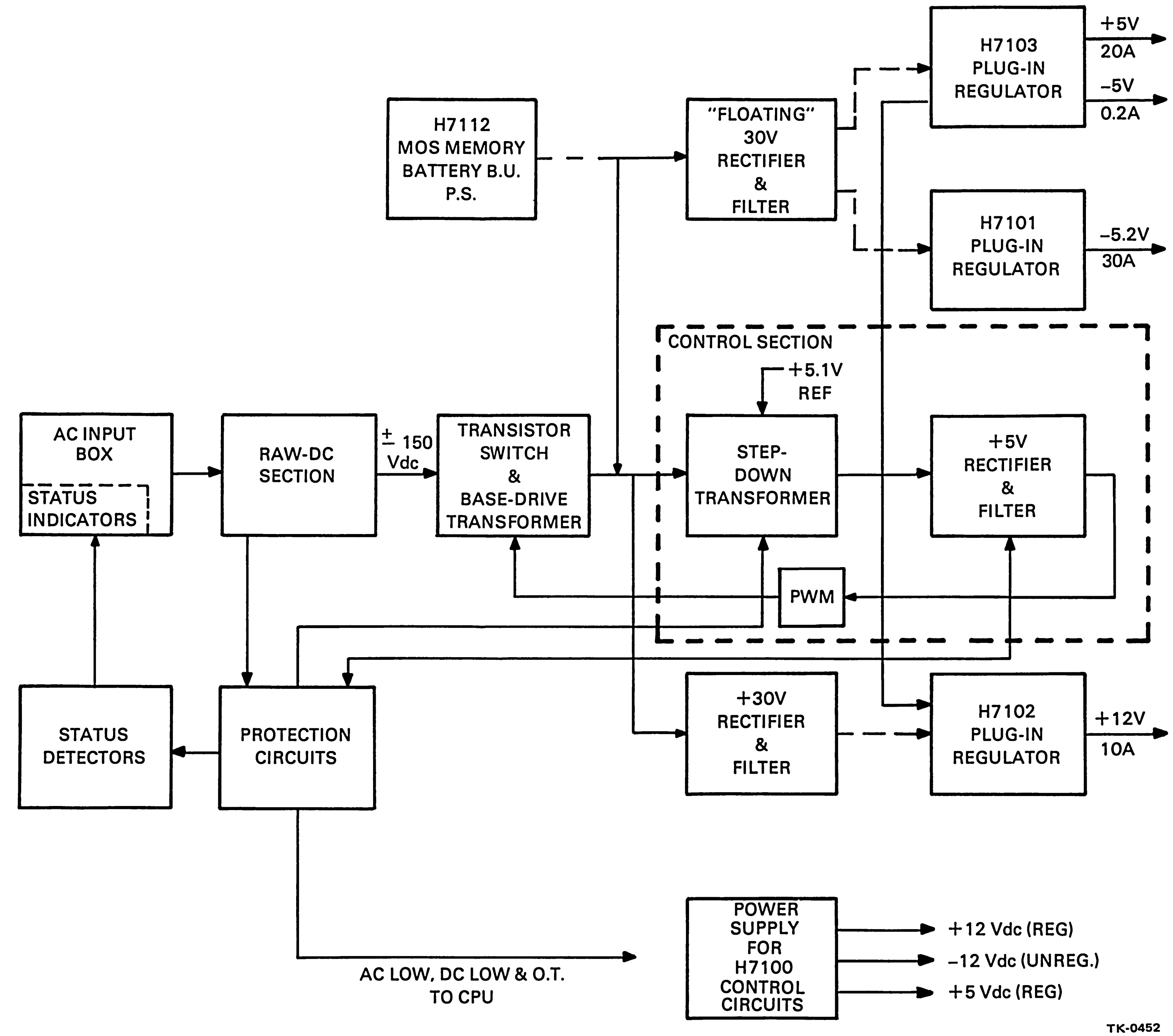


Figure 3-39 H7100 DC Power Supply – Functional Block Diagram

With one exception (the -5 B output of the H7103 at 0.2 A, as shown in Figure 4-12) the regulation of all dc output voltages is accomplished in the same way as the main +5 Vdc output. Figure 3-40 illustrates the basic regulator concept, including provision for overcurrent sensing and limiting, and crowbar load protection from overvoltage generated by the supply. Table 3-5 compares the design features in the H7100 regulator options. The floating +30 Vdc inputs to the switching buck regulators correspond to the +150 Vdc inputs to the main switching regulator (Figure 3-39). Op amp output (Figure 3-40) serves as the input (error voltage) signal to the ramp generator in which a capacitor is charged to a constant limit voltage equal to the reference. Rate of charge is proportional to error voltage and determines the projection of the maximum voltage point on the horizontal (duty cycle) axis of the ramp slope waveform. This relationship causes pulse width to vary as a function of error voltage, and is referred to as pulse width modulation (PWM). PWM frequency is determined by the 20 kHz clock. PWM output controls the duty cycle of the switching regulator (and hence the output voltage) in closed loop operation.

Figure 3-41 is a sketch identifying the +5 Vdc output and return terminals, power-fail connector J3, overtemperature connectors J4 and J5, and a cutout for installing connector J6 (H7101 regulator output) or J7 (output from H7102 and H7013 regulators).

Figure 3-42 identifies the decals affixed to individual H7100 power supplies to show their regulator complement. Table 3-6 lists the pin identifications for H7100 output connectors J6 and J7.

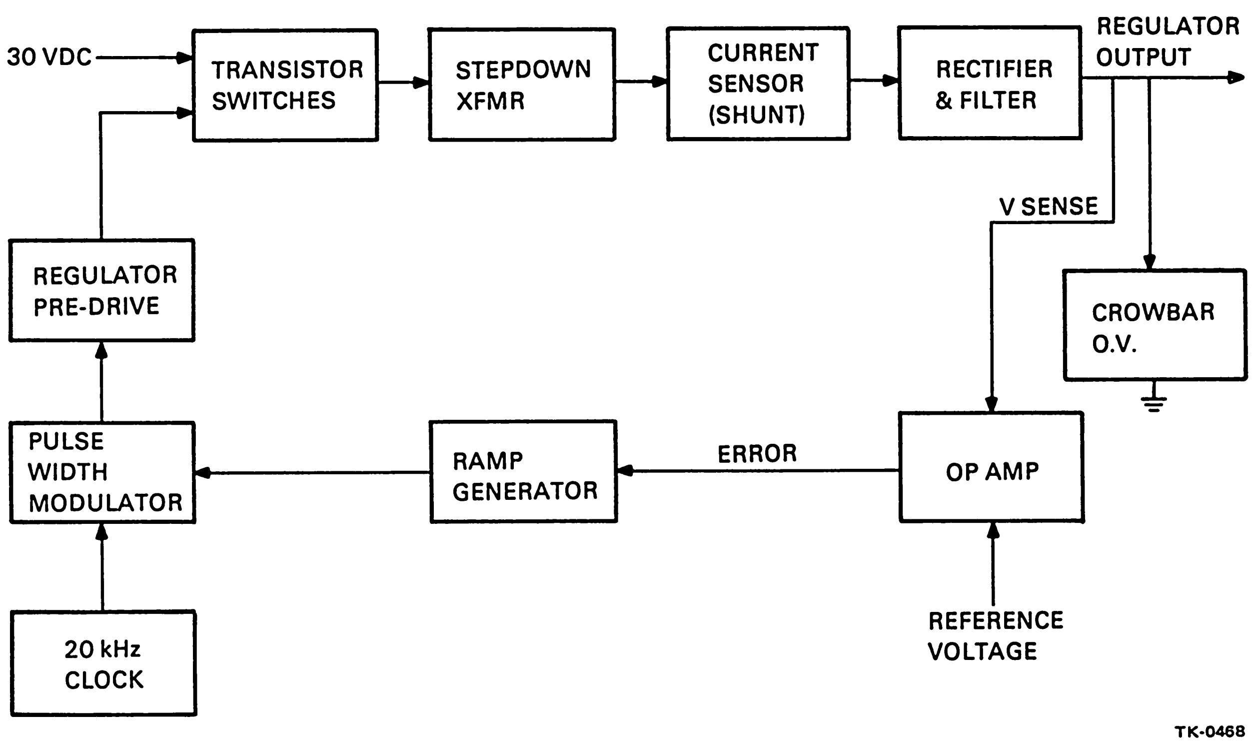


Figure 3-40 Block Diagram of Typical H7100 DC Power Supply Regulator

Table 3-5 Comparison of Regulator Features in H7100 Power Supplies

	H7101 (-5 V)	H7102 (+12 V)	H7103 (±5 V)
Base Drive Circuit	X	X	X
Power Switch	X	X	X
Error Amplifier	X	X	X (+5 B only?)
Ramp Generator	X	X	X
Clock	X	X	X (+5 B and -5 B)
Pulse Width Modulator	X	X	X
Reference Voltage Source	X	X	X
Overcurrent Circuit	X	X	X (+5 B)
Overvoltage Circuit	X	X	X (+5 B)
Crowbar Circuit	X	X	X (+5 only)
DC Voltage O.K.	X	X	X
Output Circuit	X	X	X
Status & Sequence Circuit*	–	X (on H7103)	X (-5 B) and for +12 V
Turn-off Drive Circuit	X	X	X
Flyback Diode	X	X	X
Slow Run-Up Circuit†	X	X	X
Negative Regulator	–	–	X
-5 B Regulator	–	–	X

*S&S circuit is required if the voltage goes to memory chips.

†Slow run-up provides controlled build-up of reference voltage to prevent overshoot when supply voltage is coming up from zero or from a crowbar short.

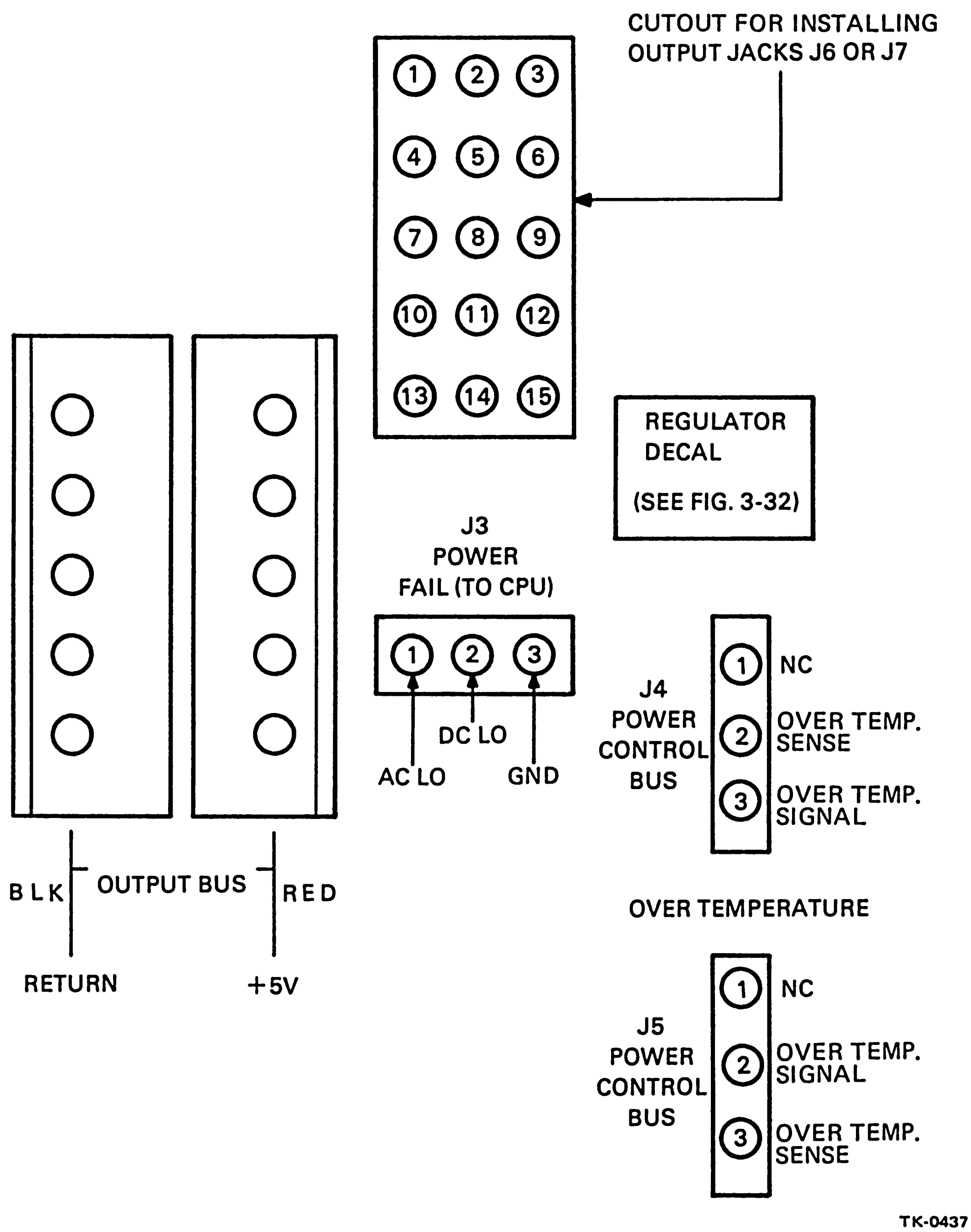


Figure 3-41 H7100 Power Supply – Rear Panel Connectors

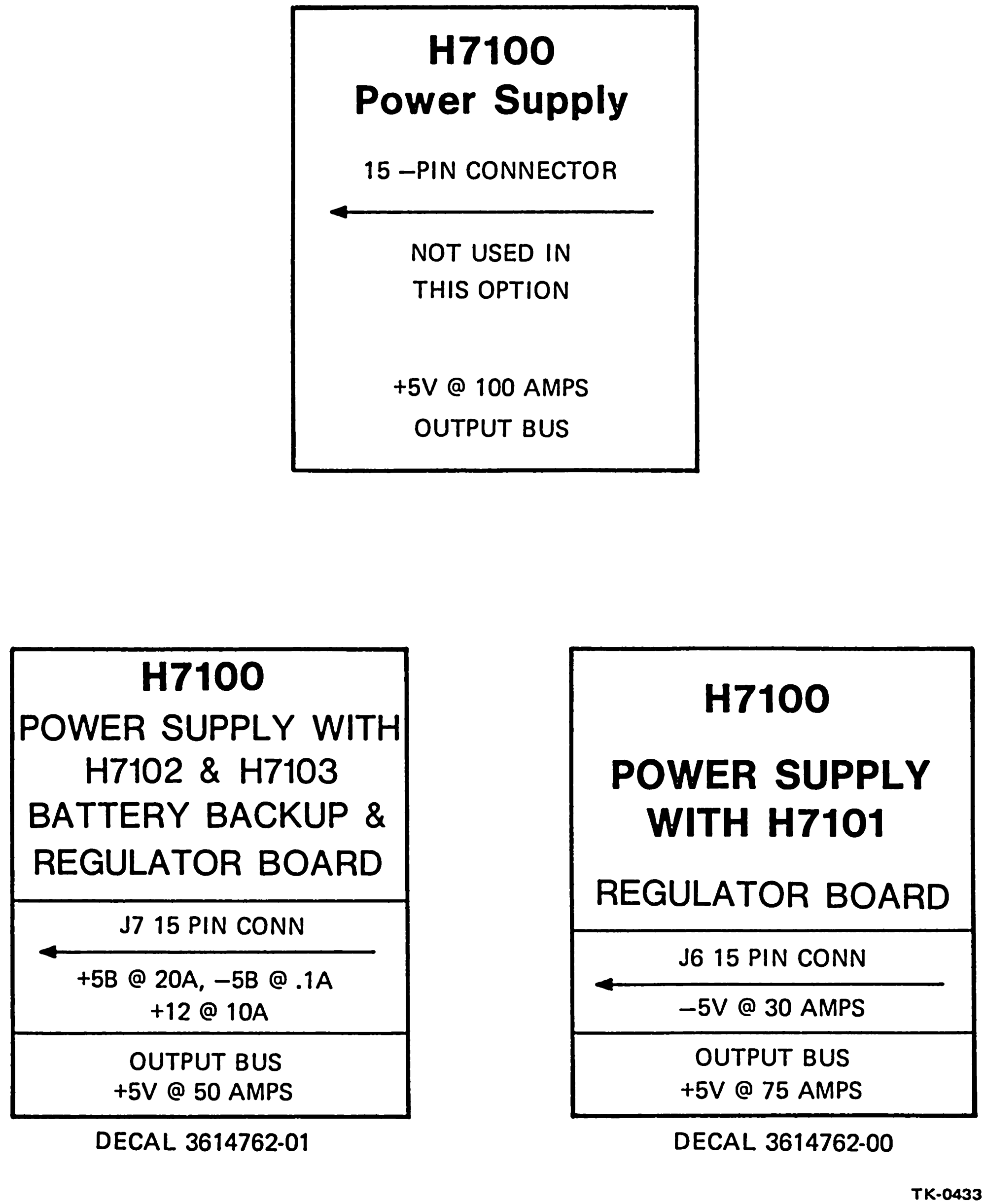


Figure 3-42 Decals Showing Regulator Complement of H7100 Power Supplies

Table 3-6 H7100 Power Supply Output Connectors J6 and J7 – Pin Identifications

J6		J7	
Pin No.	**Pin Identification**	**Pin No.**	**Pin Identification**
1	-5 V	1	+12 VB
2	-5 V	2	+12 VB
3	-5 V	3	RTN
4	-5 V	4	RTN
5	-5 V	5	+5 VB
6	-5 V	6	+5 VB
7	NC	7	+5 VB
8	NC	8	+5 VB
9	NC	9	RTN
10	RTN	10	RTN
11	RTN	11	RTN
12	RTN	12	RTN
13	RTN	13	RTN
14	RTN	14	-5 VB
15	RTN	15	-5 VB

NOTE
All return (RTN) leads are tied together.

Tables 3-7, 3-8, and 3-9 summarize the characteristics of the two power supply options (H7100A and H7100B), the regulator options, and the battery backup power supply options, respectively.

The plug-in regulator options are:

Model H7101 – delivers -5.2 Vdc at 30 A
Model H7102 – delivers +12 Vdc at 10 A
Model H7103 – delivers +5 Vdc at 20 A and -5 Vdc at 0.2 A.

The battery backup supplies designed for use with the VAX-11/780 are:

Model H7111 – delivers +5 Vdc at 0.012 A to the time-of-day clock during normal power-up operation and for a minimum power-fail period of 100 hr.

The H7111 also generates BAT DC LO.

Model H7112 – Under power-fail conditions, delivers +36 Vdc to the H7102 and H7103 regulators at a discharge rate of 250 W for 10 minutes to refresh the MOS memory. Has terminals for an external battery that can be added to extend operating time.

The H7100 dc power supply (Figure 3-43) has the following major assemblies:

1. Front panel (AC input adapter)
2. Middle panel
3. Rear panel
4. Major (mother) board
5. Control board.

Table 3-7 VAX-11/780 DC Power Supply Options

Model No.	Voltage	Input Freq. (Hz)	CB	Voltage	Output Amperes	Watts
H7100A	120	50–60	2 P-20 A	+5.1	100	500
H7100B	240	50–60	2 P-20 A	+5.1	100	500

Table 3-8 H7100 Power Supply Regulator Options

Designation	DC Output		
	Volts	Amperes	Watts
H7100	+5	100	500
H7100 with H7101 Regulator	+5	75	375
P/N 7014956-00 for 120 V supply	-5	30	150
P/N 7014956-01 for 240 V supply			
H7100 with H7012 and H7103 Regulators			
P/N 7014957-00 for 120 V supply			
P/N 7014957-01 for 240 V supply			
H7100	+5	50	250
H7102	+12	10	120
H7103	+5B	20	100
	-5B	0.2	1

Table 3-9 VAX-11/780 Battery Power Supplies

Designation	Backup For	Output	Backup Operating Time	Input Voltage and Frequency
H7111A H7111B	Time-of-day Clock Battery Supply	+5 V at 12 mA BAT DC LO	100 hr	120 V/50–60 Hz 240 V/50–60 Hz
H7112A H7112B H7112C H7112D	Memory Battery Backup Power Supply (optional)	+36 V (to +12 and ±5 regulators)	10 min at 250 W	120 V/60 Hz 240 V/50 Hz 120 V/50 Hz 240 V/60 Hz

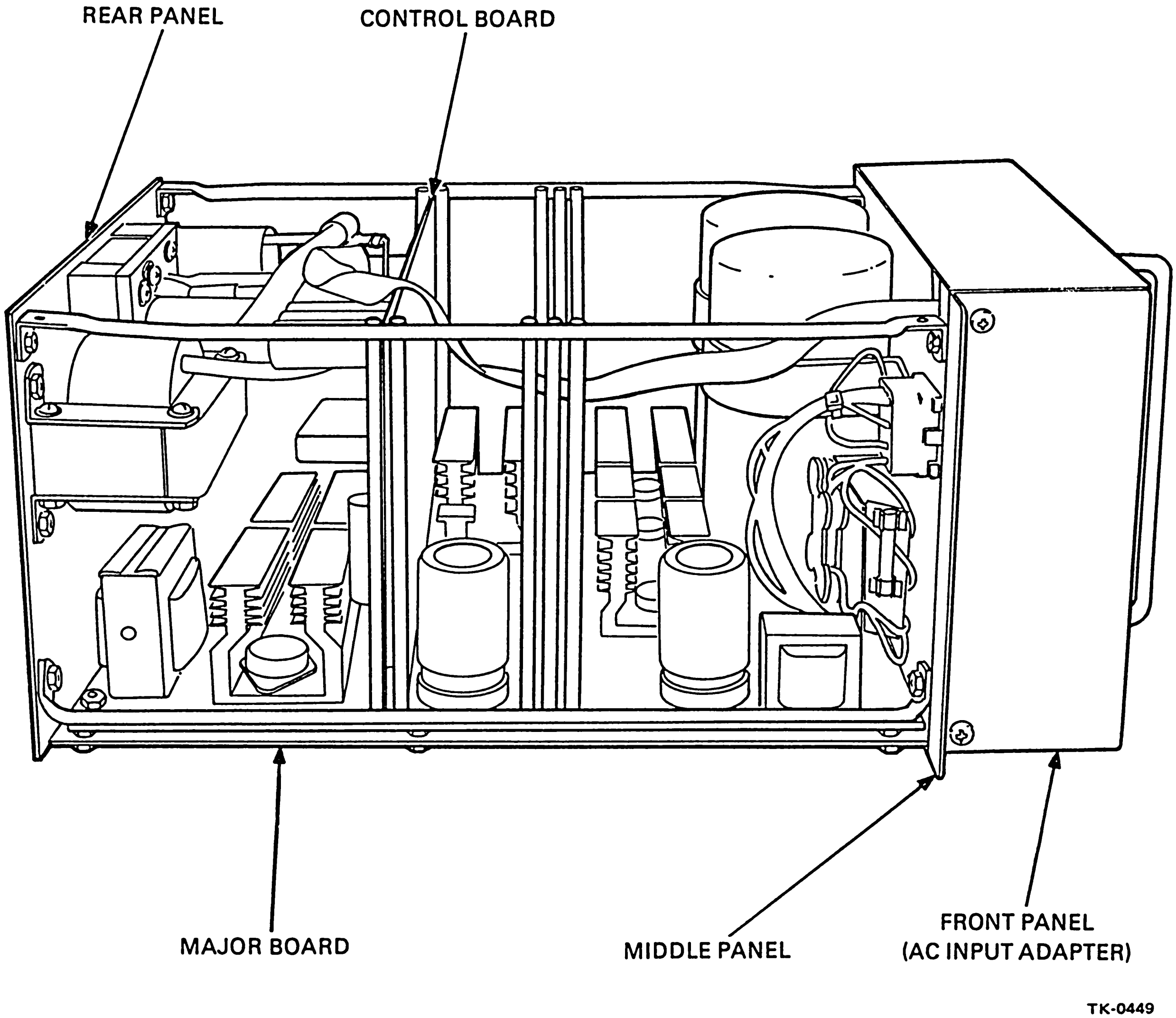


Figure 3-43 H7100 DC Power Supply – Top View

The larger components on each of these assemblies are identified in Figures 3-44 through 3-47.

Table 3-10 lists the pin identifications for the battery adapter connector (9-pin J2) at the bottom right of the H7100 front panel (Figure 3-44).

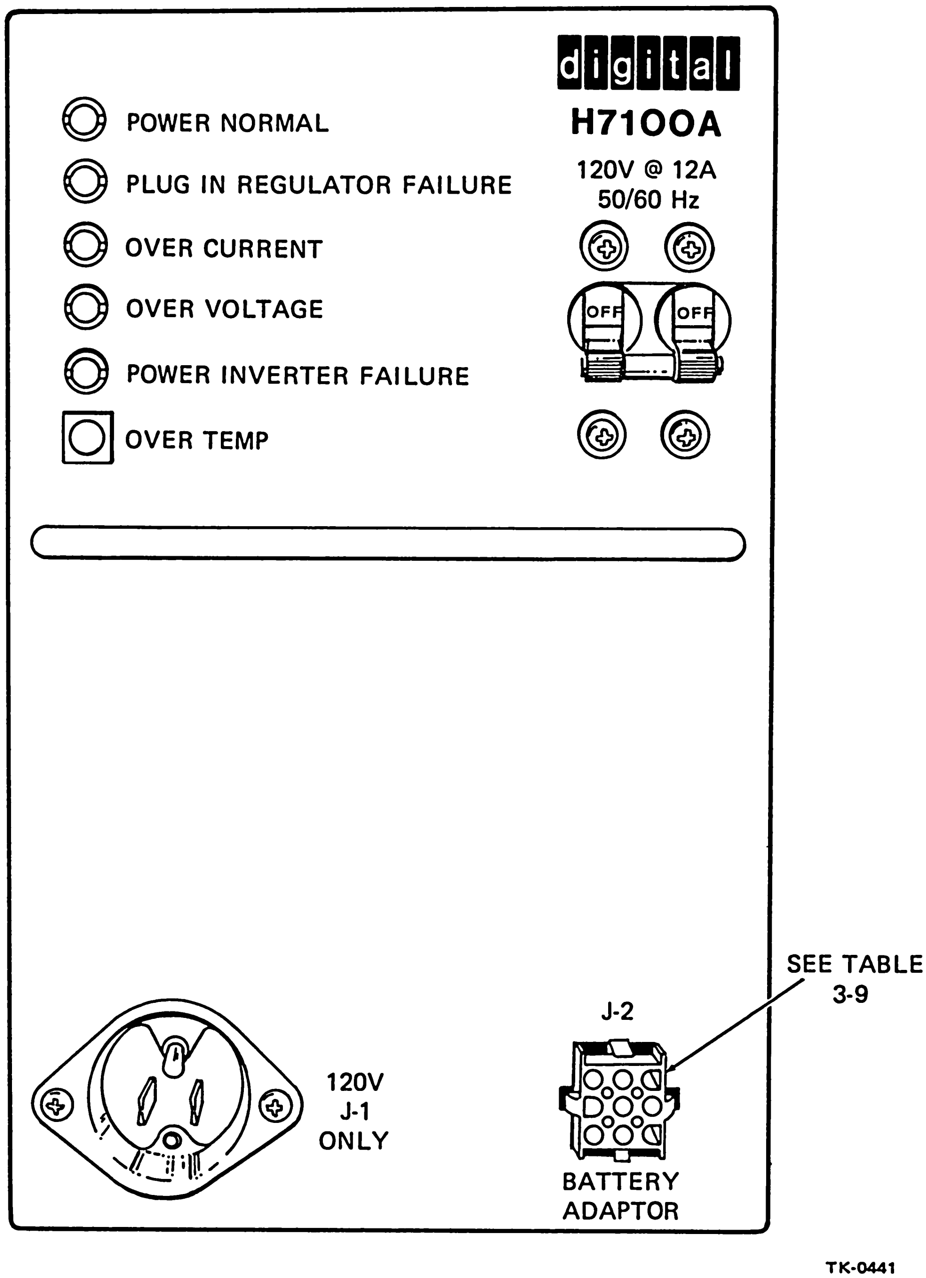


Figure 3-44 H7100 DC Power Supply Front Panel AC Input Adapter (Front View)

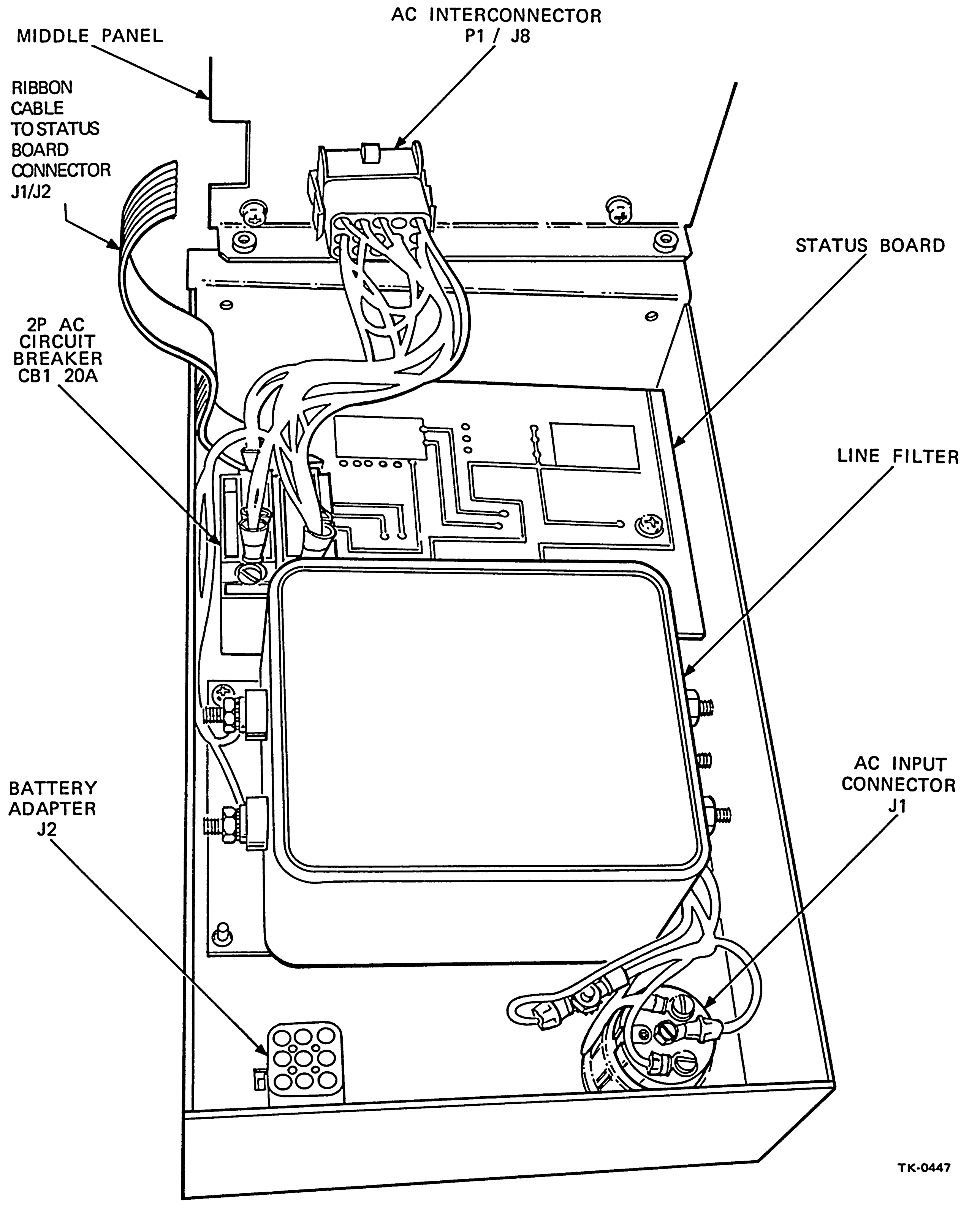


Figure 3-45 H7100 DC Power Supply Front Panel AC Input Adapter (Rear View)

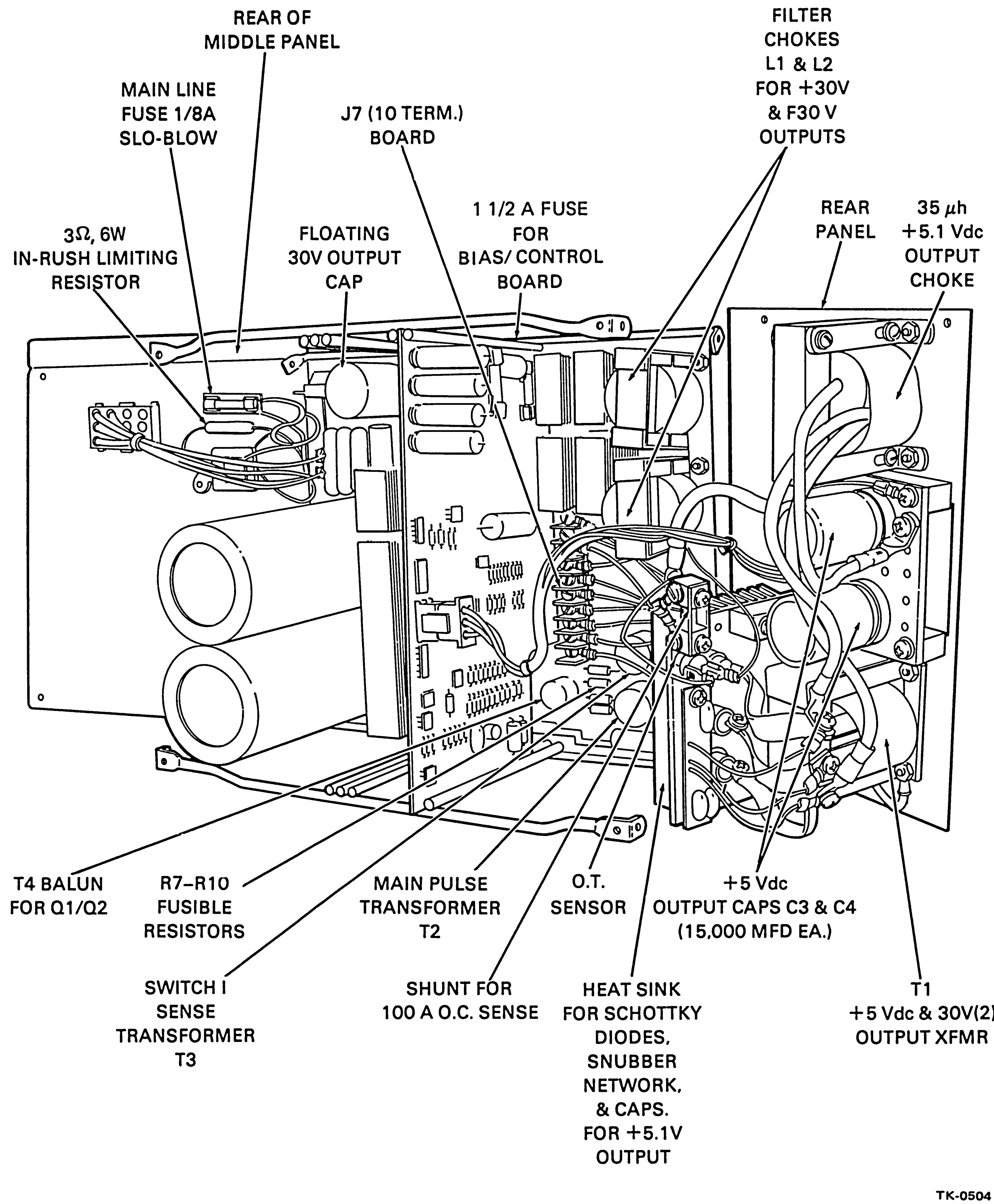


Figure 3-46 H7100 DC Power Supply – Component Identification
(Front and Rear Panels Detached from Chassis)

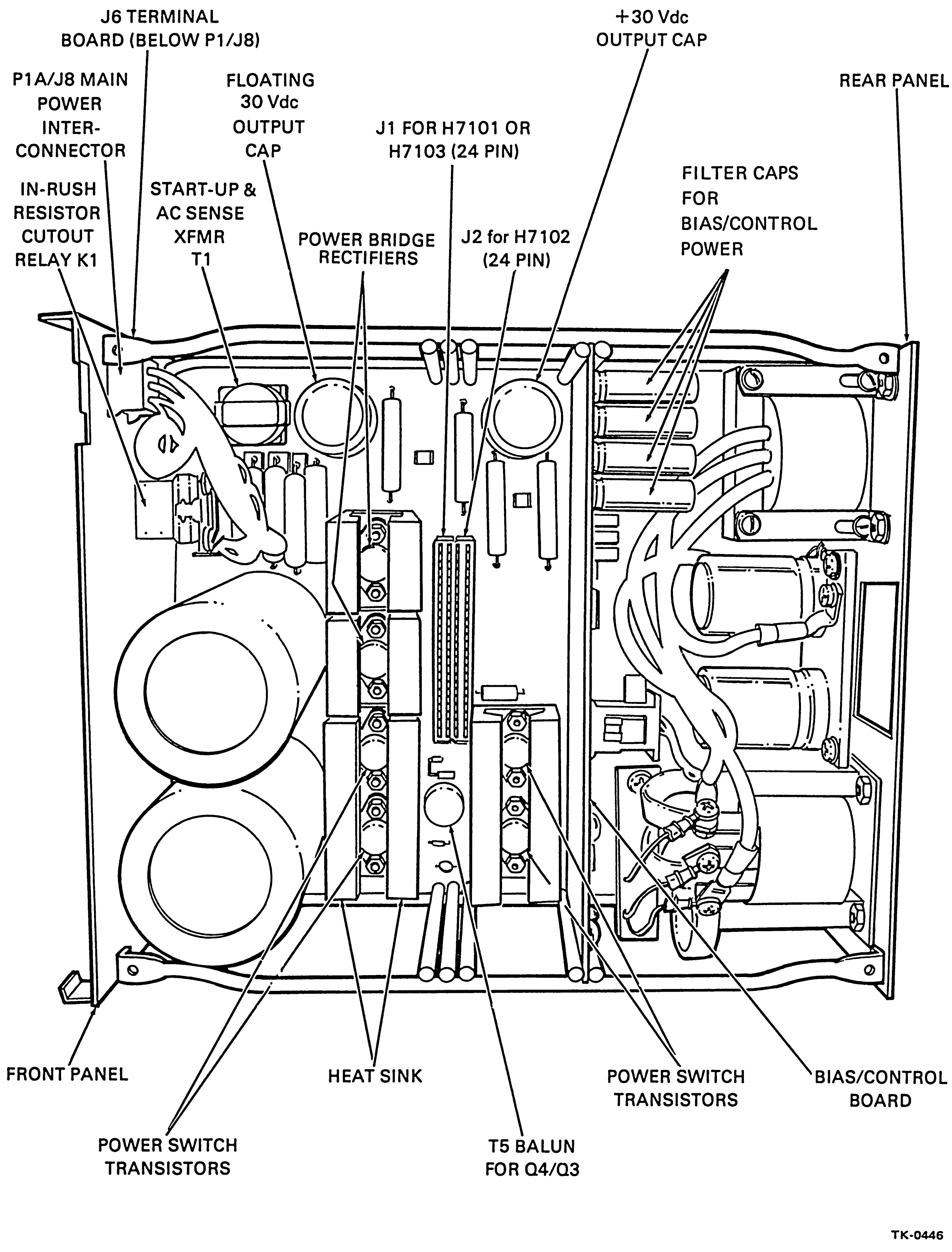


Figure 3-47 H7100 DC Power Supply – Component Identification
(Front and Rear Panels Attached to Chassis)

Table 3-10 H7100 DC Power Supply Battery Adapter (Connector) J2 – Pin Identification

Pin No.	Pin Identification
1	+36 V Battery
2	+36 V Battery
3	Relay Closure, CB1-C
4	AC LO
5	NC
6	Relay Closure, CB1-N.O.
7	+36 V Battery Return
8	+36 V Battery Return
9	NC

3.3.2.2 Block Diagram Description – The block diagram of Figure 3-39 shows the major functional areas described in the following subsections.

1. AC input
2. Raw dc
3. Transistor switch and base-driver transformer
4. 30 V section
5. Bias power supply for control circuits of H7100
6. Control section
7. Protection circuits.

AC Input
The ac adapter (front panel) (Figure 3-45) is a rectangular box that is fastened to the middle panel (Figure 3-43) by two Phillips screws. There is one adapter for 120 Vac input and another for 240 Vac input. Both adapters consist of an ac connector, line filter, 2-pole circuit breaker, power supply status board, and the plug portion of the ac interconnection plug/jack combination.

A 3 ohm resistor and a relay (K1) are mounted on the middle panel (Figures 3-46 and 3-47). K1 shorts out the resistor as soon as the input capacitors of the raw dc section are charged at power turn-on.

Raw DC
When the supply is used on a 240 V input, the rectifiers are connected as a fullwave bridge and, combined with the filters of this section, produce an output of approximately 300 Vdc. When operated on a 120 V input, this circuit functions as a voltage doubler delivering 300 Vdc at nominal line voltage. The voltage doubler is essentially two halfwave rectifiers of opposite polarity stacked in series.

Transistor Switch and Base-Drive Transformer
The 300 V raw dc is applied to a dc-to-ac inverter that chops the 300 V raw dc at a 20 kHz rate. The three outputs of the transformer are rectified and filtered to produce two unregulated 30 Vdc sources, and +5 Vdc output circuit whose regulation is effected by varying the conduction pulse width (i.e., the duty cycle). The inverter consists of two transistor switches, the power transformer, reset diodes, and snubber circuits. Each transistor switch is actually two transistors connected in parallel. Base drive to the transistors is provided by a single transformer with four secondary windings (one for each transistor) and two primary windings. One of the two primary windings is in the emitter circuit of the dc power stage and provides base drive proportional to emitter current. The other primary is tied to the inverter control circuits to provide for inverter turn-off and turn-on.

The duration of a complete cycle is 50 μs. A cycle comprises three segments: conduction, transformer reset, and dead time. During conduction, all transistor switches (Q1 through Q4) are on, connecting the dc source to the transformer primary. In the secondary, power conducted through the halfwave rectifier diodes charges the filter chokes. The voltage across the primary is the raw dc voltage (300 Vdc), while the voltage across any secondary winding is proportional to the stepdown turns ratio.

When conduction stops, the transformer magnetizing current (which builds up during the conduction portion of the cycle) continues to flow. The transformer primary voltage reverses, increasing until it reaches the level of the raw dc input, at which point the reset diodes conduct. This reset condition continues until its time equals the conduction time. During reset, the inductive energy stored in the core of the transformer is returned to the raw-dc capacitor bank. Reset is completed when the transformer primary current is reduced to zero. At this time, the circuit is at rest and no power is conducted. Dead time is maximum at high line and minimum at low line.

30 V Section

The 30 V section provides two unregulated dc outputs for the two optional plug-in regulators. The outputs of the two 30 V sections are derived in the same way as the 5 V output just described. The 30 V output is used for the +12 V H7102 regulator; the F30 V output is for the -5 V H7101 regulator. The H7103 ±5 V regulator uses both 30 V outputs and regulated +12 Vdc from the H7102 board.

Bias Supply for Control Circuits of H7100

The bias supply provides +12, -12 and +5 Vdc bias voltages for the control circuits of the H7100 and all plug-in regulator options. This supply is a flyback (single-ended switch, off-line converter) type that operates from the same raw-dc source as the main converter.

Inductive energy is built up in the primary of the transformer when the power switch (a single transistor) is on. Secondary conduction is blocked during this time by the secondary diode rectifiers. When the switch turns off, power is conducted to the load from the transformer, the inductive source. Regulation is achieved by controlling the conduction pulse width of the power switch that regulates the +12 V. The -12 V is unregulated, but closely tracks the +12 V. The +5 V bias voltage is obtained from a 3-terminal regulator operating from the +12 V source.

The start-up and ac sense transformer on the motherboard provides +12 Vac for the start-up supply/ac monitor on the bias control board. The supply/monitor circuit provides the +11 Vdc required for power supply control during the interval required for the bias supply to come up to full power.

Control Section

The control section (Figure 3-48) consists of a regulator control circuit, a clock, and a pulse amplifier. The regulator control circuit consists of the +5.1 V reference, the comparison operational amplifier, and compensation circuits, all of which control the +5 V regulation. The feed-forward circuit monitors the peak pulse voltage on the transformer secondary, which is always proportional to the raw dc voltage. This signal is used to bias the ramp generator such that the control circuit responds to changes in line voltage. The control and feed-forward signals are summed into the ramp generator to produce a delay in the PWM proportional to the sum of the two signals. This delay determines the conduction pulse width.

Protection Circuits

The output of the PWM can be shortened or interrupted by any of several circuits used to protect the power supply. Overcurrent becomes active when the +5 V output current exceeds 120 A. This circuit is a pulsing foldback type that limits the short circuit current to approximately 40 A, rms. Current pulses occur at approximately 60 ms intervals after the 120 A maximum limit is reached. The current limit circuit resets the slow run-up circuit, which then tries to restart the supply. The peak primary current limiter terminates a pulse when the switch (primary) current exceeds approximately 16 A. The crowbar sense stops all pulsing briefly when the crowbar fires.

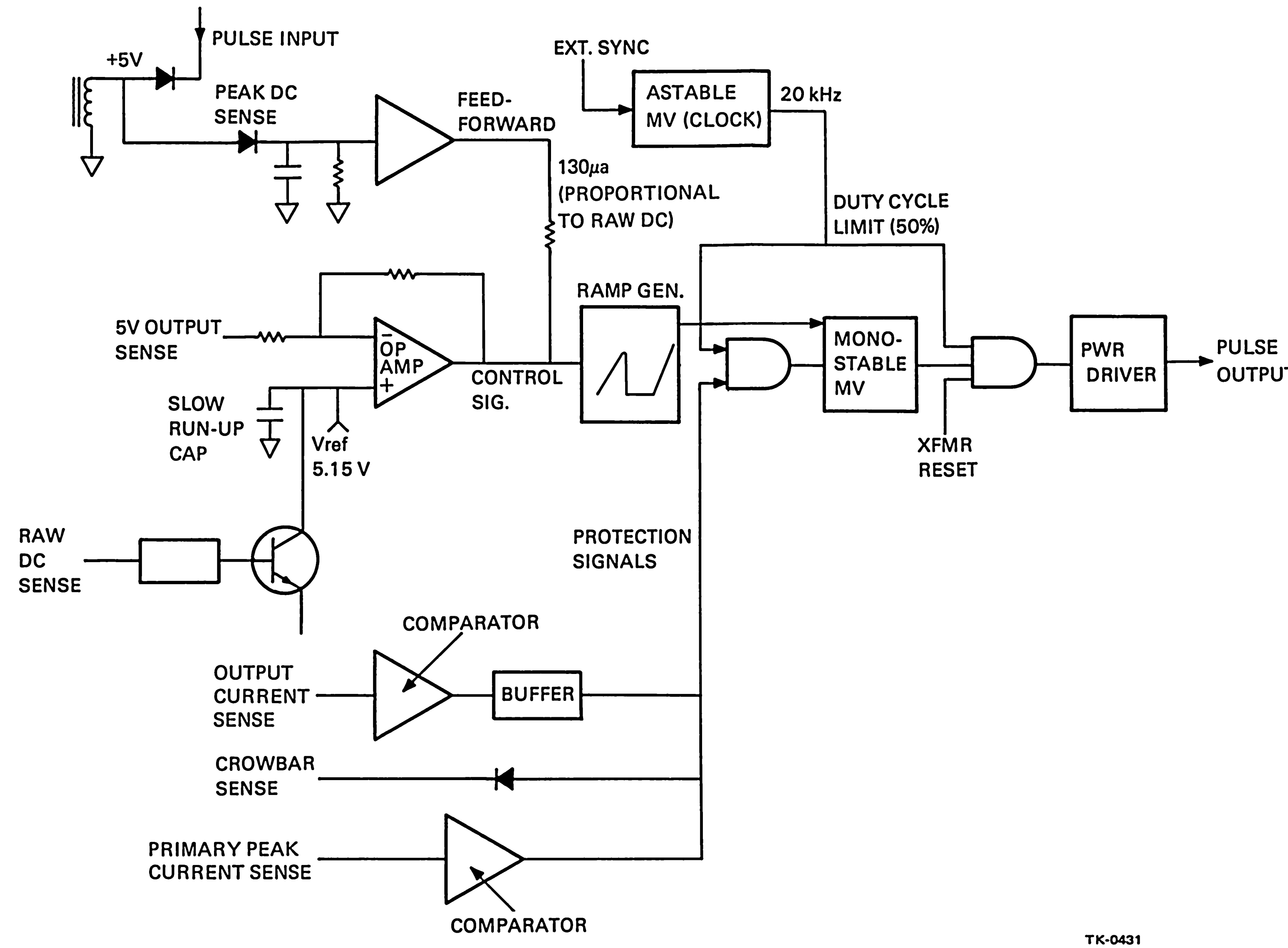


Figure 3-48 Control Circuit Simplified Schematic – H7100 DC Power Supply

3.4 POWER-FAILURE PROVISIONS

The following power-failure provisions are incorporated in the VAX-11/780.

1. Power-fail sequencing circuitry
2. Battery backup power supplies (one for the TODC, and an optional one for the memory)
3. Power-failure indicators in, and AC and DC LO signals from, the H7100 power supplies
4. Power controller overtemperature sensor
5. Cabinet air flow sensors.

3.4.1 Power Sequencing Circuit

The CPU power-fail sequencer circuit ensures that the CPU, and the 11/03 microcomputer (which acts as a CPU console) correctly respond to all power-up/power-down sequences that can be reasonably expected to occur in a system. Cases resulting from device or component failure are not considered.

The sequencer generates the power-fail interrupt for the CPU and the initialization signals that clear registers and flip-flops, and force microcode into power-up routines.

3.4.1.1 Requirements – The power-fail sequencer must satisfy constraints imposed by the SBI (Synchronous Backplane Interconnect) protocol, the Q-bus protocol, the CPU implementation, and the power system implementation. The following discussion covers the major aspects of the power sequencing circuitry.

3.4.1.2 SBI Power-Fail Constraints – Figure 3-49 is a timing diagram for the power-down/power-up sequences. The following constraints are indicated.

1. The minimum assertion time for either the FAIL (AC LO) or DEAD signals is 5 μs.

2. FAIL may be asserted without DEAD being asserted, but DEAD must always be preceded by the assertion of FAIL.

3. The requirement for an assertion time of not less than 5 ms between FAIL (AC LO) and DEAD (DC LO) allows program time for the CPU to save state in the memory and to halt.

4. The greater than 2 μs time between DEAD assertion and CLK indeterminancy allows devices such as memories to complete the cycle in progress at the assertion of DEAD.

5. The greater than 5 μs time between DEAD assertion and loss of DC PWR allows devices such as the disk controllers to stop disk activity before loss of power.

6. The greater than 25 μs time between the regaining of DC PWR and the deassertion of DEAD allows time for the clock to warm up. This interval is the minimum that the power supply must guarantee. The system will artificially assert FAIL and DEAD for an additional 100 ms that is required by the oscillator used.

7. The greater than 2 μs interval of stable clock before the deassertion of DEAD allows synchronous initialization in devices.

8. The greater than 5 μs time between DEAD deassertion and FAIL deassertion allows all initialization signals to be removed before devices attempt to set the POWER UP interrupt.

9. Minimum deassertion times for FAIL and DEAD are not specified.

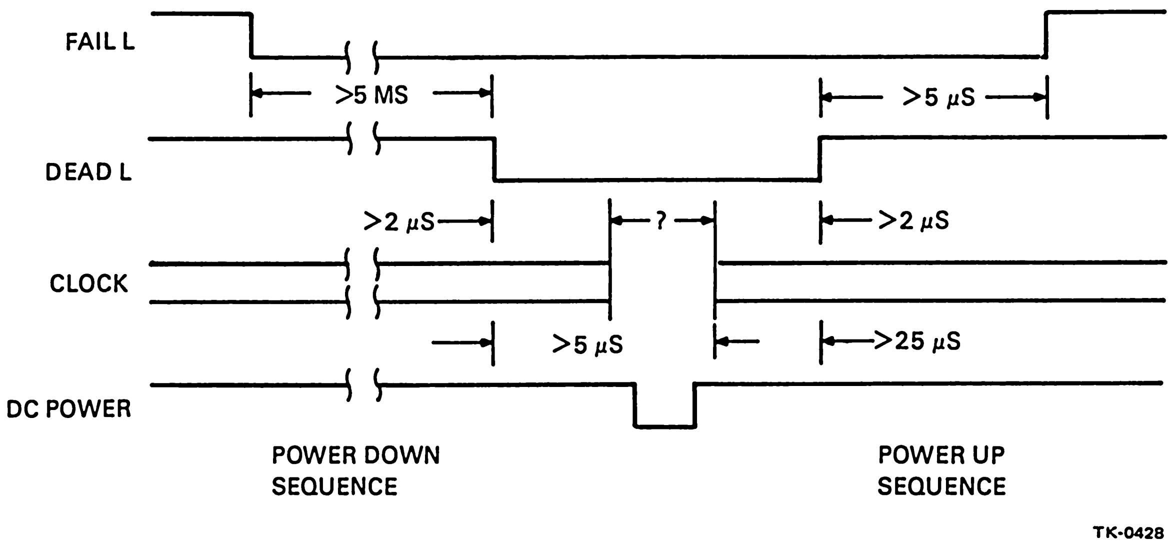


Figure 3-49 POWER DOWN/POWER UP Timing Diagram for SBI Power-Fail Conditions

3.4.1.3 Q-Bus Power-Fail Constraints – Figure 3-50 is the timing diagram for the Q-bus power-up/power-down sequence. The following constraints are indicated.

1. The assertion of BPOK (Q-BUS AC LO) requires 8 ms of dc power reserve and the previous assertion of BDCOK (Q-BUS DC LO) for at least 70 ms. With these requirements satisfied, BPOK must then be asserted for at least 3 ms.

2. BPOK deassertion requires a dc power reserve of 4 ms and the deassertion of BPOK for not less than 1 μs.

3. BDCOK (DC LO) assertion requires that dc power was good for the preceding 3 ms and the assertion of BDCOK for at least 1 μs.

4. BDCOK deassertion must occur 5 μs before the loss of DC power, but at least 4 ms after the deassertion of BPOK (AC LO). BDCOK must be deasserted for at least 1 μs.

Because of the several (up to 5) independent power supplies used in VAX-11/780 systems, the minimum assertion times established for BPOK (AC LO) and BDCOK (DC LO) cannot be guaranteed. If minimum assertion times for these parameters are not achieved, the effects on the 11/03 microprocessor and other Q-bus devices can be significant. For example, if BPOK is deasserted during a power-up routine and is not followed by a BDCOK deassertion, the microprocessor is left in a hung condition. For this reason, the power-up and power-down routines must be so designed that the system is insensitive to the invocation of a power-down routine before the power-up routine is completed.

Since the console system (including the 11/03 microprocessor) does not preserve any processor state for the duration of a transient power failure, the system is insensitive to the incompletion of a power-up routine if BDCOK is deasserted in order to clear the possible hung condition, and force the microcode routine back to the beginning of the power-up routine.

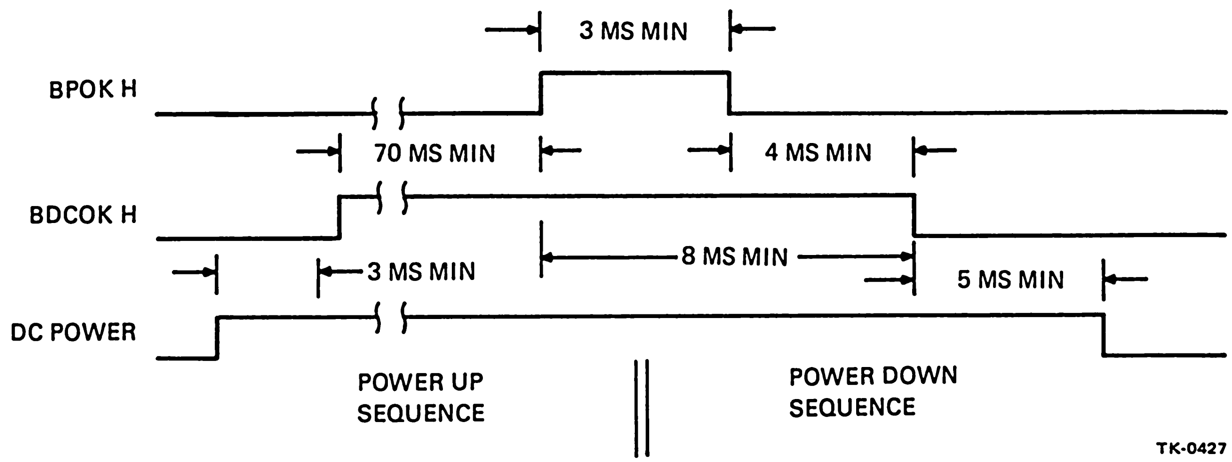


Figure 3-50 POWER UP/POWER DOWN Timing Diagram for Q-Bus Power-Fail Conditions

3.4.1.4 CPU Constraints – Inasmuch as the 11/03 microprocessor and its power supply are part of the CPU system hardcore, both must be functioning before the CPU can operate. From a system viewpoint, both CPUs and their power supplies must interact in the following manner.

1. Any failure or outage of a CPU power supply or the 11/03 power supply should cause both CPUs to fail; i.e., the first power supply to assert AC LO will cause assertion of the system AC LO signal and deassertion of Q-BUS BPOK H (AC LO).

2. Neither CPU will recover and power up until all power supplies are operating normally; i.e., the last supply to release DC LO and AC LO causes the deassertion of system DC LO and AC LO; it also deasserts Q-BUS BPOK H (AC LO) and BDCOK H (DC LO), thereby powering up both CPUs.

3. Since the SBI interface is included in the hardcore, the assertion of CPU system AC LO and DC LO must be caused by the assertion of FAIL (AC LO) and DEAD (DC LO) on the SBI.

4. To avoid multiple interrupts in brownout conditions, and to ensure proper sequencing of the CPU and the 11/03 microprocessor, the following protocol is enforced within the system.

   a. AC LO and DC LO and their equivalents in the SBI and Q-BUS (i.e., BPOK H, FAIL, etc.) must remain asserted by the power supply or other driving device for a minimum of 5 μs. It should be noted, however, that a similar constraint concerning minimum deassertion time cannot be made because of the asynchronous nature of these signals. For example, when AC LO L goes high there is the possibility that another supply will immediately assert it, pulling it low again. The result is the possible deassertion of AC LO and DC LO for arbitrarily short periods. However, a minimum 5 μs assertion can be guaranteed if all drives meet their specifications.

   b. The AC LO seen by the CPU and the 11/03 must, once asserted, remain asserted for at least 5 ms in order to prevent multiple power-fail interrupts.

   c. At the end of the 5 ms AC LO assertion, DC LO (as seen by the CPU and the 11/03) must be asserted for at least 1.0 μs in order to force microcode in both CPUs into initialization routines.

d. AC LO (as seen by the 11/03, and hence the rest of the system) must remain asserted for a minimum of 70 ms after the negation of system DC LO. This constraint is imposed by the 11/03 and various Q-bus peripherals, but will not hurt system performance because power up may not be completed without intervention by the 11/03 anyhow.

e. Under normal conditions, DC LO should not be asserted unless AC LO is asserted.

It should be noted that a CPU system power failure does not cause the assertion of FAIL and DEAD on the SBI. The location of the SBI clock and terminator in the CPU backpanel is such that the SBI protocol for these signals is correctly executed, being independent of CPU internal operation.

3.4.1.5 Power System Constraints – The H7100 supplies (but not the 11/03's supply) conform to SBI timing constraints, FAIL L being equivalent to AC LO H and DEAD L being equivalent to DC LO H. As indicated, the minimum assertion time of the fail signals can be guaranteed, but minimum deassertion cannot be.

Barring catastrophic failure, each power supply will be so designed as to guarantee the following.

1. DC LO will never occur without AC LO.
2. AC LO can be asserted without DC LO.
3. The minimum assertion time of AC LO or DC LO is 5 μs.
4. AC LO is asserted at least 5 ms before DC LO.
5. AC LO is asserted for a minimum of 5 μs after DC LO deassertion.
6. Power is good for 5 μs after DC LO assertion.
7. Power is good for 25 μs minimum before DC LO deassertion.

It will be recalled that the CPU receives its power from as many as three supplies; the 11/03 microprocessor has its own internal power supply.

3.4.1.6 Circuit Description – The circuits used to implement the CPU power-fail and initialize sequencing are located on the clock (CLK) module. The drivers and receivers for the Q-bus are located on the console interface (CIB) module.

Fail-Safe Bus Drivers
To guarantee the integrity of the SBI and Q-bus power-fail signals (FAIL, DEAD, BPOK, BDCOK) during transitions of the power supply output, special drivers are required for these signals. An N-channel J-FET is used in a common-source configuration to drive the bus power-fail signals. The J-FET is seen as a 10-ohm resistance to ground when the gate source voltage is approximately zero. When this potential is more negative than –7 V, the J-FET appears as an open circuit to ground and the drain is pulled up to +3 V by the bus terminator.

Each power supply in the CPU asserts AC LO H and DC LO H by guaranteeing that the output voltage at these terminals is zero. AC LO H and DC LO H are deasserted by applying –12 V to these terminals.

The AC LO H and DC LO H outputs of the power supplies should not be wire-ORed, but the contrary is true for the drains of the J-FETs. Each supply can drive as many of the J-FETs as is necessary. A circuit identical to the bus driver and in parallel with it is used to generate internal AC LO L and DC LO L.

The CPU power-fail and initialize circuit uses a set of four J-FETs with wire-ORed drains to generate each of the following signals:

FAIL L	(SBI)
DEAD L	(SBI)
BPOK H	(Q-bus)
BDCOK H	(Q-bus)
PS AC LO L	(CPU)
PS DC LO L	(CPU).

Other Bus Drivers and Receivers
The signals that drive the SBI and Q-bus power-fail signals artificially (to meet system constraints) will always have good power at the times they are relied upon and can therefore be standard, open-collector TTL gates. The bus power-fail signals must be received with a low-input current, high-threshold bus receiver; i.e., DEC 8640. The received bus signals used by the sequencer circuit are:

DEAD L
FAIL L
AC LO L (Q-bus, buffered BPOK H).

The power-fail receivers are buffered from any edge-triggered circuits by a "glitch catcher" for the power-fail deassertion edge of the signals. The filtering provided by the "glitch catcher" is necessary because, in the "last one to let go releases the bus" implementation, transients will occur on the bus when the current from a just-released driver redistributes among the still-asserted driver or drivers. The length of the transients will be one round trip time on the bus or less. The circuit used filters out transients up to 100 ns (approximately), which is approximately two round trips on the SBI or the Q-bus.

Inputs and Outputs
Figure 3-51 shows the inputs and outputs of the power-fail sequencer circuit. This circuit is edge triggered from AC LO, but is self-restoring. Thus, without continued assertion of a DC LO equivalent the normal state will be resumed. The console reset input forces SYSTEM INIT (U Program initialize) without affecting the remainder of the sequencer circuit.

3.4.1.7 Sequencer Operation – The power-fail sequencer circuit is triggered from the assertion edge of ORed AC LO equivalents; a signal called AC LO OR FAIL. This signal clocks the power-fail interrupt flop and is used as a 1-bit BEN (branch enable) test by microcode. Assertion of power-fail interrupt results in the starting of the power-fail timeout and the setting of the FORCE AC LO flop. At the end of timeout, FAKE DC LO is set, which in turn sets the FORCE DC LO flop. FAKE DC LO is an internally generated DC LO equivalent and is ORed in with the other DC LO equivalents. The ORing of the DC LO equivalents sets the FORCE DC LO flop and causes the assertion of the SYSTEM INIT, and the UPROG (U-Program) INIT signals that initialize the CPU.

On the deassertion edge of the ORed DC LO equivalents, a 3 ms timeout to clear FORCE DC LO starts. After FORCE DC LO is cleared, a 70 ms timeout to clear FORCE AC LO is started. Once FORCE AC LO is cleared, the circuit is ready to accept another power-fail signal.

A maintenance circuit, activated by grounding a backpanel pin, causes the power-fail sequencer circuit to cycle repeatedly through a series of power fails and returns.

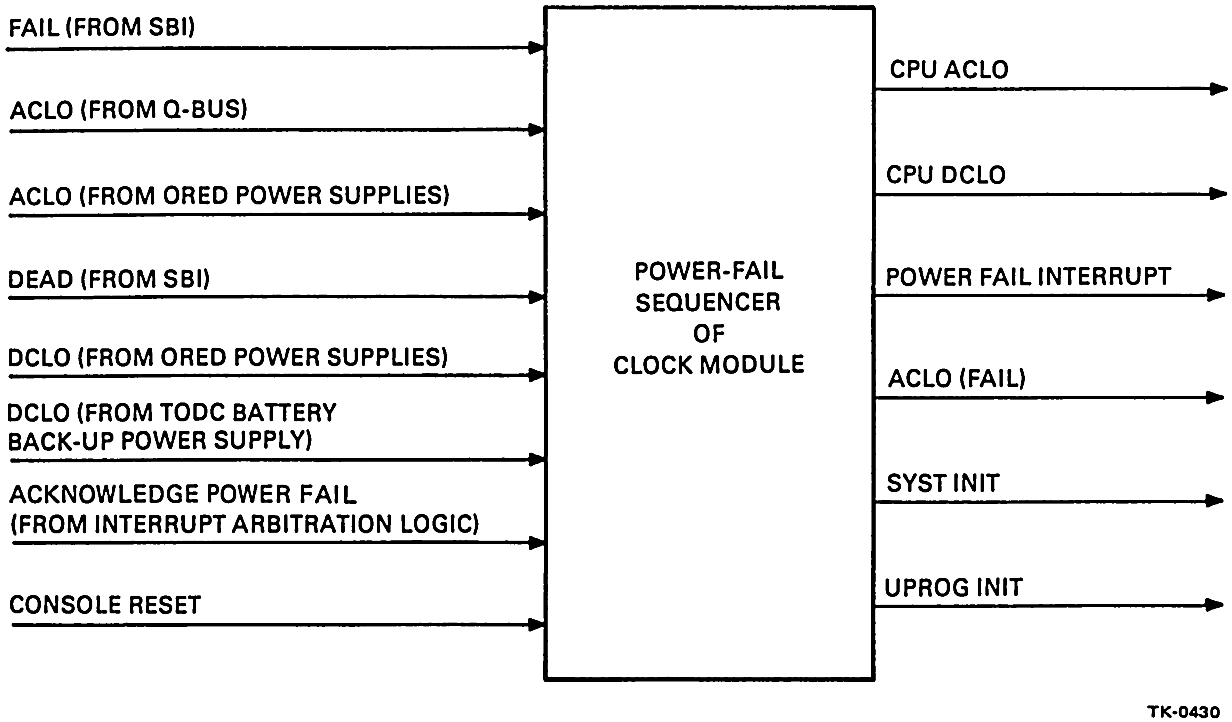


Figure 3-51 Power-Fail Sequencer – Inputs and Outputs

3.4.1.8 Power Sequencing Terminology

FAIL Signal
The FAIL signal is asserted by NEXUS* (whose existence in the system is necessary for the proper restart after a power failure, i.e., memory and CPU NEXUS. The purpose of FAIL is to provide a restart signal to the CPU, so that a system restart operation may be initiated. CPUs are the only NEXUS that recognize the FAIL signal.

Assertion of FAIL
A NEXUS asserts FAIL asynchronous to the SBI clock during the assertion of the power supply AC LO at that NEXUS. The assertion of FAIL inhibits CPUs from activating a power-up routine. SBI bus operation may continue during the assertion of FAIL.

Deassertion of FAIL
FAIL is deasserted asynchronously when all NEXUS required for the power-up routine operation have detected the deassertion of AC LO. CPUs sample the FAIL signal at an appropriate time after a power-down routine (assertion of FAIL) to determine if a power-up routine should be enabled.

DEAD Signal
The DEAD signal is asserted asynchronously to the SBI clock when an impending power failure to the clock circuit or bus terminating network is detected. NEXUS attached to the bus use this signal to prevent invalid data from being received while the bus is in an unstable state. NEXUS may not assert any SBI signal when DEAD is asserted. Dead is to be interpreted as a reset function equivalent to NEXUS DC LO.

*Any device connected to the SBI (synchronous backplane interconnect).

Assertion of DEAD
The assertion of power supply DC LO to the clock circuit or terminating networks causes the assertion of DEAD. DEAD is asserted asynchronously to the SBI clock and occurs at least 2 μs before the clock becomes inoperable. When the clock is inoperable due to power loss, its behavior is unpredictable.

Deassertion of DEAD
DEAD is deasserted when DC LO is deasserted at the clock circuit or terminating networks. The clock is operational for at least 2 μs before the deassertion of DEAD.

3.4.2 Battery Backup Power Supplies

The basic VAX-11/780 system includes a battery backup power supply for the system time-of-day clock, and an *optional* battery backup power supply for refresh of the MOS memory is also available. Both supplies operate as uninterruptable power sources having dual-rate chargers and self-contained batteries. When a power line outage or voltage dip occurs, both supplies are automatically transferred to a mode in which the batteries take over the functions of the associated dc power supplies.

3.4.2.1 H7112 Memory Battery Backup Power Supply – The H7112 comprises:

1. A constant-current, dual-rate battery charger
2. Three 12 V, 5 A/hr, sealed lead-acid batteries (DEC P/N 12-12499-00).

When fully charged, the battery pack will supply up to 250 W into a constant power load for 10 minutes. The power required from the external battery is 280 W. Recharge time is 14 to 16 hr. For other H7112 performance specifications, refer to Table 2-9.

Mechanical Configuration
The H7112 (Figures 3-52 and 3-53) is housed in a rack-mountable cabinet that is side and top ventilated by natural convection through louvers. The cabinet weighs approximately 11.25 kg (25 lb) and has the following dimensions:

Height – 13.2 cm (5.2 in)
Width – 48.3 cm (19.0 in)
Depth – 15.6 cm (6.2 in)

Interchangeable input assemblies permit operation from either 120 or 240 Vac supplied by the power controller of the cabinet containing the H7112 unit (refer to the ac power distribution diagrams of Figures 3-10 and 3-11). Two auxiliary battery terminals (J12 and J13) enable connection of an external battery supply if extended holdup time is desired. However, a charging circuit is not provided for this external source. Since the internal and external batteries are diode-buffered only, their load-sharing characteristics and relative discharge rates will depend upon the particular situation.

Two 3-pin connectors (J10 and J11 at the rear of the unit) provide for H7112 interface with the DEC power control bus in order to effect shutdown of the H7112 whenever the emergency shutdown command appears in the bus.

The output connector J7 is mounted on the single PC board (5412675) in the H7112. Connections to the 11/780 are via a cable entering the left side of the unit (refer to detail A of Figure 3-52).

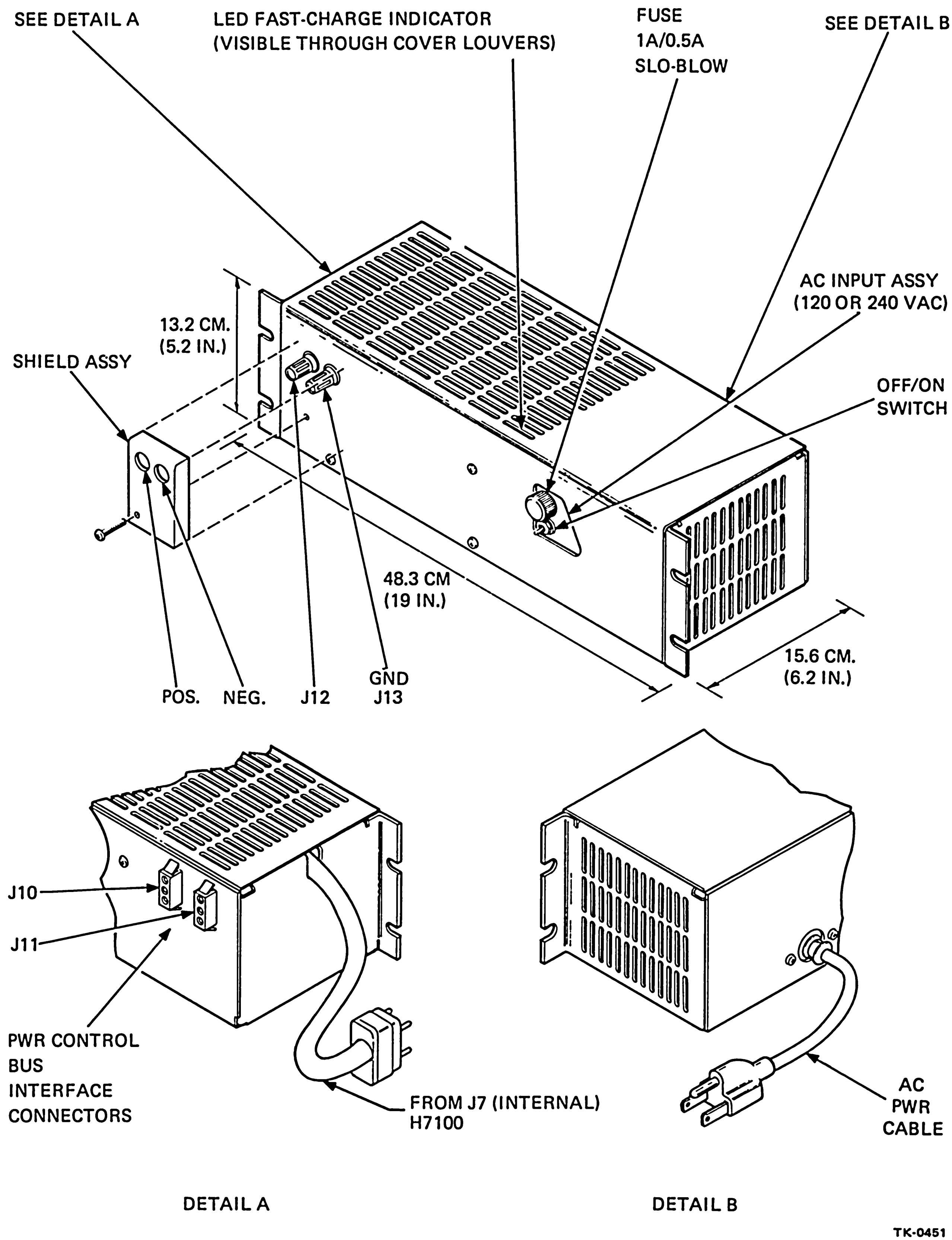


Figure 3-52 H7112 Memory Battery Backup Power Supply – External View

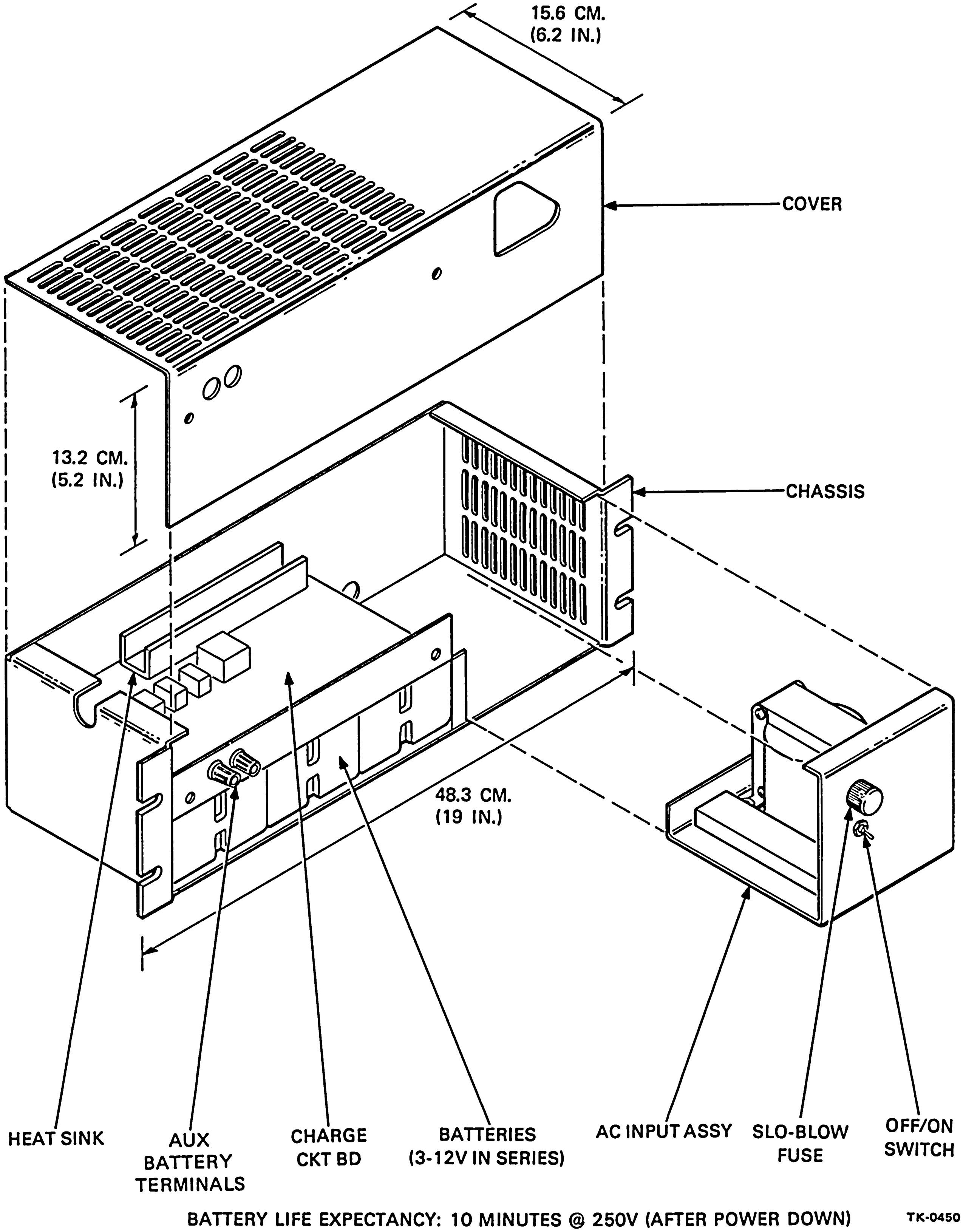


Figure 3-53 H7112 Memory Battery Backup Power Supply – Interior View

Electrical Characteristics
The H7112 battery charger circuit is comprised of the following:

1. An ac input assembly
2. Rectifier
3. Bias voltage supply
4. Fast/slow charger
5. Battery-out circuit
6. Emergency shutdown circuit.

Figure 3-54 is a simplified electrical schematic of the charger.

AC Input Assembly
The AC input assembly (Figures 3-53 and 3-54) consists of an ac input cable with plug, a 4-pole, 2-position ON/OFF toggle switch, S1, a slo-blo fuse, F1, a barrier strip used in changing from 120 to 240 Vac, constant-voltage transformer, T1, and output connector P1. This entire assembly is replaced when going from 120 Vac to 240 Vac operation, or vice versa.

The following circuits are on the 5412675 PC board of the H7112.

Rectifier
The low-voltage ac from T1 is fed to the rectifier bridge via connector P1/J1. The voltage developed across capacitor C1 is 50 to 70 Vdc.

Bias Voltage Supply
This circuit provides the +15 vdc bias voltage for the various control circuits in the H7112.

Fast/Slow Charger
The charger operates as a constant-current source. When the batteries reach a 90 percent charge stage, the fast/slow charge circuit switches automatically to a trickle charge that is maintained until the battery is needed for power down or power dip situations. While the H7112 is operating in its fast-charge state, a LED is turned on, being visible through the top louvers of the cover. Charge rates for two modes are 500 mA and 10 mA, respectively.

Battery Out Circuit
If an outage occurs, the generation of an automatic ACLO signal by the H7100 power supply causes a transistor switch to turn on, supplying the full battery voltage (36 Vdc) to the H7102 and H7103 regulators of the H7100 power supply. The H7102 normally supplies +12 Vdc at 1 to 10 A; the H7103 provides +5.0 Vdc at 2 to 20 A and –5.0 Vdc at 0 to 0.20 A.

The corresponding power available under battery backup is:

From H7102: +12 Vdc at 4.6 A
From H7103: +5 Vdc at 18.5 A, and –5 Vdc at 0.2 A

A sense circuit on the BATT OUT line monitors the dc voltage at the input to the regulators of the H7100 dc power supply so as to ensure that initial dc voltage is available. An AC OK signal (–12 ±3 Vdc) is sensed and, when AC LO is asserted (AC OK goes to ground), the battery takes over and supplies dc voltage to the regulators.

When the initial voltage level of the battery at takeover (approximately 40 Vdc) has decreased to 27 V, the battery voltage low-sense circuit disconnects the batteries to protect them from deep discharge.

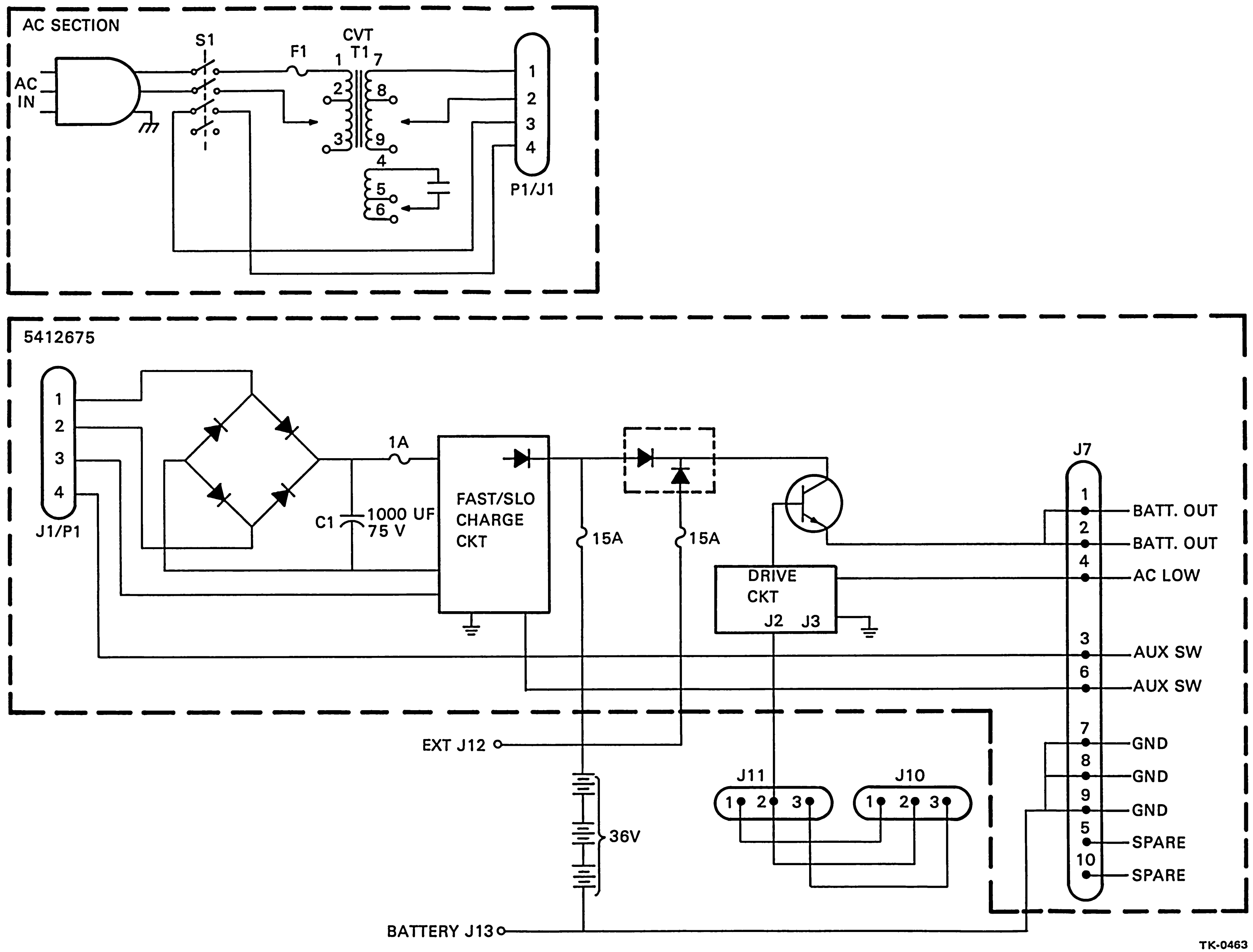


Figure 3-54 H7112 Memory Battery Backup
Power Supply – Electrical Schematic

If the DEC power control bus senses a thermal problem, it will inhibit the battery output voltage by connecting pin 2 of either J10 or J11 to ground (EMERGENCY SHUTDOWN – refer to Paragraph 3.2.1, Power Control Bus).

In series with a relay coil (not shown in the schematic) is a set of contacts on the ON/OFF switch (S1) and two pins on the BATT OUT connector J7. If the ON/OFF switch is in the OFF position, or if closure of the relay is not provided across pins 3 and 6 of J7 (AUX SW), no battery charging or battery out voltage is available.

To charge the batteries when the H7112 is out of the system, the following steps must be taken.

1. On the interface (BATT OUT) cable, pin 3 must be jumpered to pin 6 and pin 1 to pin 8.
2. The H7112 must be plugged into a proper ac outlet.
3. The ON/OFF switch (S1) must be set to its ON position.

Emergency Shutdown
If a thermal problem develops in the 11/780 system, a ground is asserted between J2 and J3 (Figure 3-54), thereby turning off the transistor switch in the BATT OUT line.

CAUTION

An important consideration in storage of the DEC 12-12499-00 lead-acid battery is its storage temperature. With storage temperatures above 18.5° C (65° F), the acceptable storage period falls off significantly, becoming as short as 6 months at 35° C (96° F).

3.4.2.2 H7111 Time-of-Day Clock (TODC) Battery Power Supply – The H7111 is comprised of the following:

1. A constant-current, dual-rate battery charger
2. One 12 V, 5 A/hr, sealed lead-acid battery (DEC P/N 12-12499-00).

When fully charged, the battery will supply 5 Vdc at 25 mA for at least 100 hours. Recharge time is less than 24 hours. For other H7111 performance specifications refer to Table 2-8.

Mechanical Configuration
The H7111 (Figure 3-55) is housed in a rack-mountable cabinet that is side and top ventilated by natural convection through louvers. The cabinet weighs approximately 2.25 kg (5 lb) and has the following dimensions:

Height – 8.9 cm (3.5 in)
Width – 48.3 cm (19 in)
Depth – 10.2 cm (4.0 in).

Primary power for the H7111 is supplied by the controller of the main cabinet (refer to the AC Power Distribution System of Figures 3-10 and 3-12). The +5 Vdc, BAT DC LO, and GND outputs are sent to the TODC, but the +12 Vdc output is for test only.

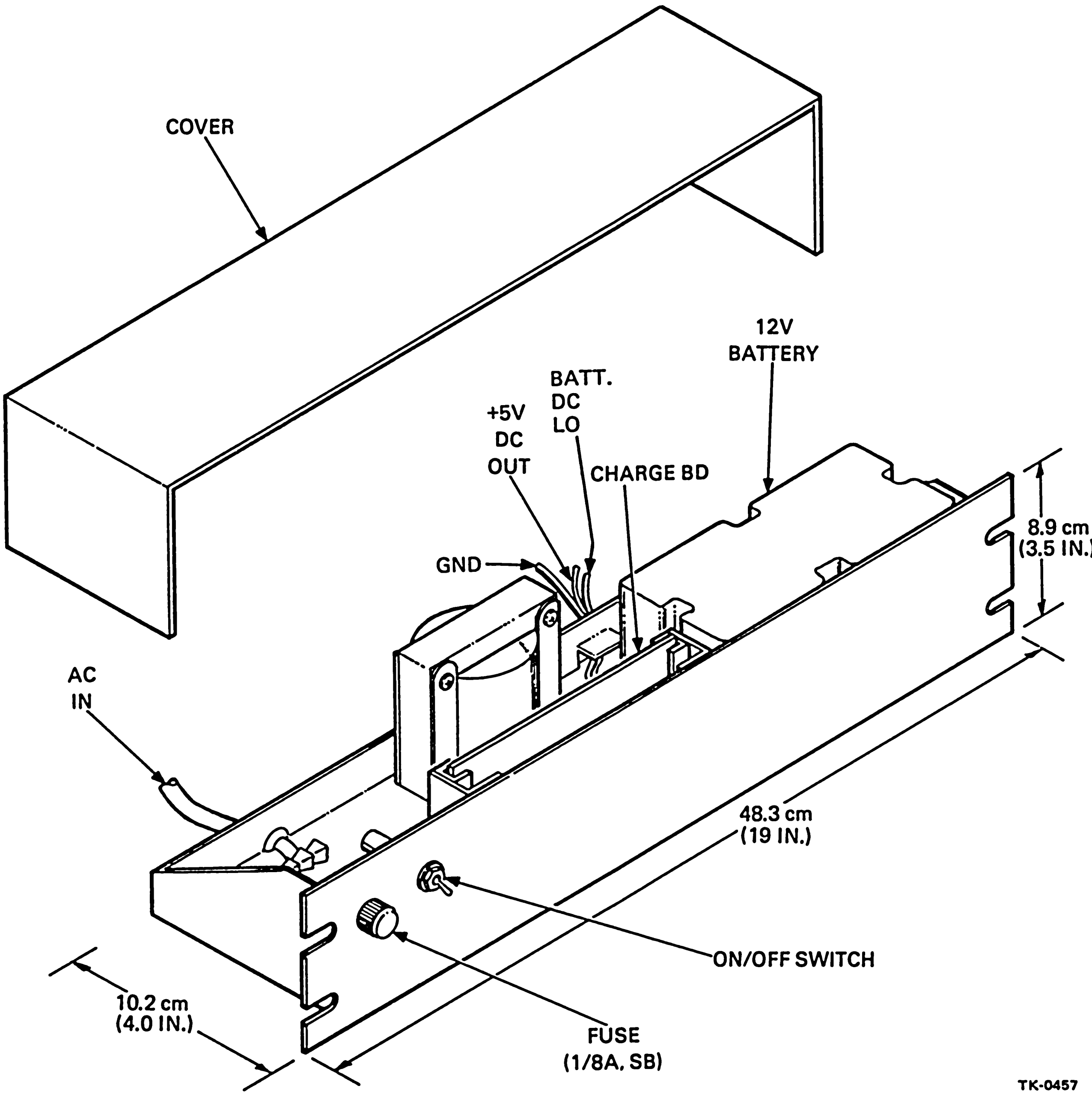


Figure 3-55 H7111 Time-of-Day Clock Battery Power Supply

Electrical Characteristics

Dual-Rate Battery Charger
The charger (see the simplified electrical schematic of Figure 3-56) comprises:

1. Input cord and plug assembly
2. Stepdown transformer
3. Bridge (full-wave) rectifier and filter
4. Trickle charge circuit
5. Fast charge circuit
6. Charge level control circuit
7. Battery low-voltage detector
8. Battery low-voltage disconnect relay
9. 5 V regulator
10. Battery DC LO generator.

Input Cord and Plug Assembly
The 1.1 m (3.5 ft) 3-wire line cord connects to the transformer at an input terminal board.

Stepdown Transformer
The stepdown transformer (120 Vac or 240 Vac primary, depending on the system installation) supplies approximately 22 Vac, rms.

Rectifier and Filter
The solid-state bridge rectifier output is filtered by a 1900 μf capacitor whose size maximizes the average dc output. A 2.2 KΩ, 1 W resistor serves as a bleeder and, in the event that fuse protection is lost, as a load.

Trickle Charge Circuit
The trickle charge circuit uses a zener diode/transistor combination as a current source providing a 10 mA trickle current to the battery and 22 mA to the H7111 control circuits.

Fast Charge Circuit
The fast charge circuit also uses a zener diode/transistor combination to provide a 215 mA charging current to the battery.

Charge Level Control Circuit
The charge level control circuit controls only the fast charge current source, turning it on or off as required. When battery voltage reaches 14.6, which represents a 90 percent charge state, the fast charge current source turns off. Turn-on reoccurs when battery voltage falls below 13.0 Vdc. At power up, the unit always starts up on fast charge.

Battery Low-Voltage Detector
The purpose of the battery low-voltage detector is to protect the battery by disconnecting it when terminal voltage falls below 10.5 Vdc. Operation assumes that no line voltage is present; otherwise, discharge would not have occurred. Detection of the 10.5 Vdc level causes closure of a transistor switch in the low-voltage detector circuit. Switch closure opens the coil circuit of a battery-disconnect relay. Relay unlatching disconnects the battery from the fast charge circuit.

The battery then remains disconnected until primary power is regained, fast charge comes on, and the battery voltage rises to 11.6. At this point, the relay pulls in to reconnect the battery to the fast charge circuit. The low-voltage detector uses a single transistor and one section of a 3-section LM339 comparator.

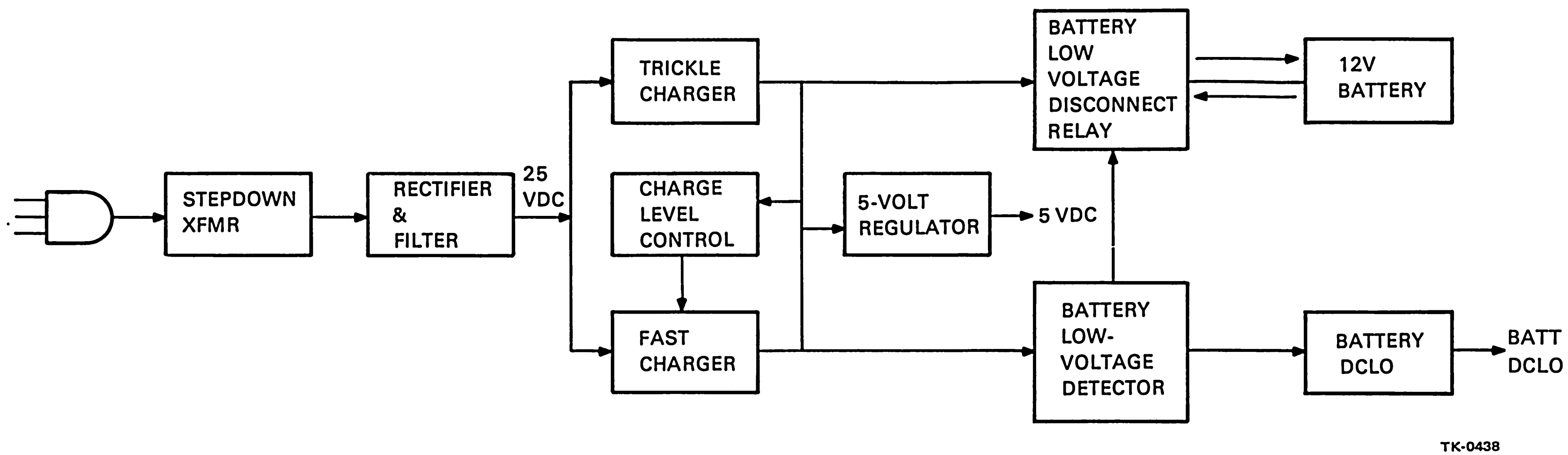


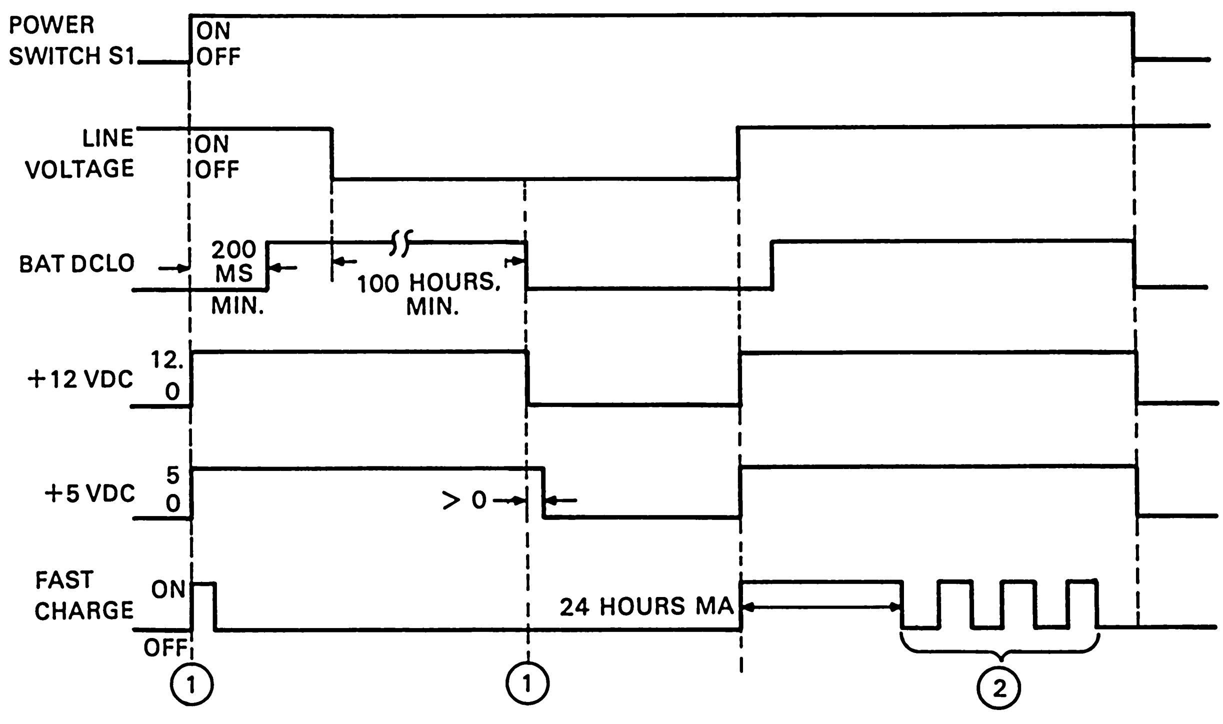
Figure 3-56 H7111 Time-of-Day Clock Battery Power Supply – Block Diagram

Low-Voltage Battery Disconnect Relay
The battery disconnect relay is a very low coil current type used as a latch. Its function was described previously.

5 V Regulator
The purpose of the 5 V regulator is to provide the required +5 Vdc to the time-of-day clock during power outages or voltage dips, using the battery as its power source. The 3-terminal 7805 is used in the H7111. This regulator has an internal current-limit feature and is heat-sinked by contact with the etch on the H7111 PC board.

Since maximum load current is 25 mA, 7805 power dissipation is very low. Diode buffering keeps the trickle charge current source independent of load variations.

Battery DC LO Generator
Like the AC LO and DC LO signals generated by the H7100 dc power supply under power-fail conditions, the BATT DC LO generated by the H7111 goes to the CPU where it is used in decision processes relative to the loss of +5 Vdc for the TODC. BATT DC LO is generated by a p-channel FET that is turned on by one section of the LM339 3-section comparator and results from turn-off of the low-voltage disconnect relay, and shorting of capacitor at the input to the comparator to effect its turn-off. The FET is normally on until its gate is made 6 V more positive than the source for complete turn-off. On power up, the charging time for the capacitor at the input to the comparator results in a 200 ms delay before BATT DC LO goes high (refer to the timing diagram of Figure 3-57). BATT DC LO H is +4 to 4.5 Vdc; BATT DC LO L is less than 0.4 Vdc.



NOTE 1
ASSUME BATTERY WAS FULLY CHARGED (90% CAPACITY).

NOTE 2
FAST CHARGE MAY CYCLE UNTIL BATTERY CHARGE IS TOPPED OFF AT ABOUT 125% CAPACITY.

TK-0439

Figure 3-57 H7111 Time-of-Day Clock Battery Power Supply – Timing Diagram

12 V Lead-Acid Battery (DEC P/N 12-12499-00)
The H7111 12-12499-00 battery is a 5 A/hr, sealed lead-acid type whose 6 cells deliver a terminal voltage of 12 Vdc. As previously indicated, terminal voltage varies appreciably with battery charge state: e.g., at 90 percent of full charge, voltage is 14.6; at full discharge, voltage is 10.5.

The H7111 is on fast charge mode at power up and whenever terminal voltage falls below 13.0 Vdc. Trickle charge replaces fast charge when voltage has risen to 14.6 (90 percent charge point). At 10.5 V, battery state is "full discharge" and auto disconnect occurs.

CAUTION
Discharge to less than 9 Vdc can cause permanent damage to the battery.

After one week on trickle charge, battery voltage will level off at 14.2, the battery then being at approximately 120 percent charge.

CAUTION
An important consideration in storage of the DEC 12-12499 lead-acid battery is the storage temperature. With storage temperatures above 18.5° C (65° F), the acceptable storage period falls off drastically, becoming as short as 6 months at 35° C (96° F).

3.4.3 Power-Failure Provisions in the H7100 DC Power Supply
The power-failure provisions incorporated in the H7100 are as follows.

1. Front-panel status indicators providing visual indication of:
   a. POWER NORMAL condition
   b. Plug-in regulator failure
   c. Overcurrent condition
   d. Overvoltage condition
   e. Power inverter failure.
2. A reflective indicator for an overtemperature condition within the supply.
3. AC LO and DC LO outputs to the CPU.
4. An OVERTEMPERATURE SENSE signal for the power controller.

Power Normal
When lit, the POWER NORMAL lamp indicates that all dc outputs from the H7100 are normal. For this condition to exist, the other four status lamps must be unlit; i.e., there can be no regulator failure, no overcurrent condition, no overvoltage condition and the power inverter must be functioning normally.

Plug-In Regulator Failure
When lit, the PLUG-IN REGULATOR FAILURE lamp, merely indicates that one of the plug-in regulators is malfunctioning; since it does not indicate which one, the operator must perform instrument checks to isolate the defective board.

Overcurrent
The overcurrent lamp lights when the load current of the +5.1 Vdc supply rises to 120 A. It does not indicate overcurrent conditions existing on other H7100 dc output lines. Pulsing is stopped when the 120 A limit is exceeded.

Overvoltage
The overvoltage lamp lights when the regulated +5.1 Vdc voltage malfunctions and produces an output reaching 6.2 or more Vdc. When lit, this lamp also indicates that the crowbar has fired, a condition that causes the H7100 to turn off. However, automatic reset occurs after approximately 100 ms and, if overvoltage still exists, the overvoltage lamp will reilluminate. This cycle will repeat itself until the power supply circuit breaker is set to OFF.

Power Inverter Failure
When lit, the POWER INVERTER FAILURE lamp indicates a hardware failure on the H7100 motherboard. Under battery backup conditions, this lamp will remain lit, but in this case a power inverter failure would be unlikely since the power-fail condition preceding battery backup would not produce inverter failure.

Overtemperature
The overtemperature lamp is a reflective indicator that illuminates when the 100° C sensor on the heat sink for the output rectifiers turns on. Note that sensor output is fed to controller via a 2-wire cable leading from parallel-wired connectors J4 and J5 on the rear panel of the H7100 supplies (Figure 3-41). J4 and J5 connect with TOTAL SHUTDOWN connector J9 at the rear of the 869 controller or with daisy-chained J1 and J3, the power control bus connectors, on the 866 controller. In the latter case, the overtemperature signal will shut down all power supplies on "switched" power, but the memory power supply, blower number 2 (adjacent to the memory card cage) and the battery backup power supplies will remain energized. The overtemperature sensor on any power supply can initiate shutdown of the entire system (or the switched loads in the case of the 866 controller), but cannot effect direct shutdown of the power supply in which they are located. If an overtemperature condition occurs, the dc input from the H7112 memory battery backup power supply automatically disables.

AC LO and DC LO
These outputs, initiated on the bias/control board of the H7100, are transmitted to the CPU so that suitable power-fail sequencing can be effected to cope with a sensed imminent power-fail situation. AC LO (i.e., AC LO deasserted) is –9 Vdc. When asserted (failure imminent) AC LO goes to 0 Vdc. DC LO has the same signal levels as AC LO.

3.4.4 Power Controller Overtemperature Sensor
Each of the DEC standard power controllers used in VAX-11/780 systems incorporates an ambient-air overtemperature sensor. The sensor is mounted on the left side of the controller chassis in the 866 and at the rear of the chassis in the 869 (to the right of the total shutdown connector, J9, as seen from the rear of the chassis). In all cases a small (3/4 in diameter) cutout exposes the sensor to ambient air in the vicinity of the controller; e.g., Figure 3-15.

In the 866 controllers, activation of the overtemperature sensor causes shutdown of all devices on switched power only. In the 869 controllers, activation of the overtemperature sensor causes a total shutdown of the cabinet in which the particular controller is located, operating independently of the power control bus. Thus, cabinets other than the one experiencing the overtemperature can continue to operate.

3.4.5 Air Flow Sensors

Each of the impeller-type blowers in the main cabinet (normally three blowers) and the single blower in the SBI cabinet (Figure 3-3) has an associated air flow sensor unit. The location and operation of these sensors was discussed earlier (869D Controller). In Figure 3-11, the air flow sensors are shown as AFS 1 through 3.

NOTE

The air flow sensor control box (7015036) that provides +15 Vac for sensor actuation is the same as the air flow interface shown in Figure 3-22. This unit is not required with the 869 controller because the +15 Vdc is provided by it.

3.5 CABLING

VAX-11/780 main cabinet cabling falls into three basic areas:

AC interconnections
Power control signal interconnections (e.g., PCB, OT, AFS)
Backplane dc interconnections.

Data cables are not covered in this power systems manual.

3.5.1 AC Interconnections

Sheet 1 of Figure 3-7 illustrates the cabling configuration of the VAX-11/780-C/D main cabinet. The item numbers on this sheet are explained in the tables provided by sheets 2, 3, and 4. For each item these tables show the associated part number, item description, and "from–to" cable locations. Three tabulations are given CA/DA for 115 Vac, 60 Hz; CB/DB for 230 Vac, 50 Hz; and CC/DC for 115 Vac, 50 Hz.

In Figures 3-19 and 3-21 (rear views of the 866D and 866E power controllers), the 120 V (866D) or 240 V (866E) duplex outlets are identified as J9 through J15; with the exception of receptacle polarization, the backpanel configurations of the two controllers and the loads assigned to each receptacle are identical. The single-line diagram of Figure 3-10 shows the ac power distribution for systems using the 866 controller. Figure 3-12 shows the same distribution for the 869 power controller.

Referring again to sheet 1 of Figure 3-7, the loads connected to the power controller are:

1. Six H7100 dc power supplies (although space for 6 supplies is provided, the actual number used will vary with the particular system configuration. In the minimum "C" configuration, only 3 H7100s are used; in the "D" configuration, 4 H7100s are used. If the FP780 option is included in either configuration, an additional supply is provided for it. Thus, in VAX-11/780 systems presently available, a maximum of 5 H7100s will be used.)

2. Three impeller-type blowers (numbers 1, 2, and 3)

3. 11/03 microprocessor

4. H7111 TODC battery backup power supply

5. H7112 memory battery backup power supply (optional)

6. RX01 floppy disk

7. 7015036 air flow sensor control box (air flow interface).

The 11/03 and RX01 have integral power supplies that are powered through the 866 controller.

3.5.2 Power Control Signal Interconnections

In an overview sense, the power control signal interconnections provide:

1. Bus connections from power controller connectors J1 and J3 to the individual overtemperature output connectors (J4 and J5) on each power supply rear panel; these connectors are daisy-chained from supply to supply.

2. Bus connection from the power controller (connector J3) to the System Control Panel (SCP) at the top front of the main cabinet.

3. Overtemperature bus connection from the H7112 memory battery backup power supply (connector J1) to PS No. 2 (connector J5).

4. SCP connection to the RX01 floppy disk.

5. Air flow sensor power connection to the air flow sensor control box and control signal connection from sensor to power controller via the power control bus.

3.5.3 Backplane DC Interconnections

Drawing D-IC-11780-0-3 of the print set details the dc interconnections between:

1. The dc power supplies and the logic modules.
2. The RX01 floppy disk, SCP, and KA780-A CPU.

Sheet 2 of the referenced drawings provides item descriptions and cable termination data similar to that provided for Figures 3-7 and 3-8 of this power system manual.

A quick-reference, single-line diagram showing these power supply to logic module connections is given in Figure 3-37. Also shown in this diagram are voltage and current characteristics for each load.

3.6 GROUNDING

The only grounding external to the main cabinet is for the disk drives (RP05/06, RK06 or RM03). The required cables are installed as part of the system installation (*VAX-11/780 System Installation Manual*, EK-SI780-IN-PRE).

To verify that the prescribed grounding has been accomplished, see that:

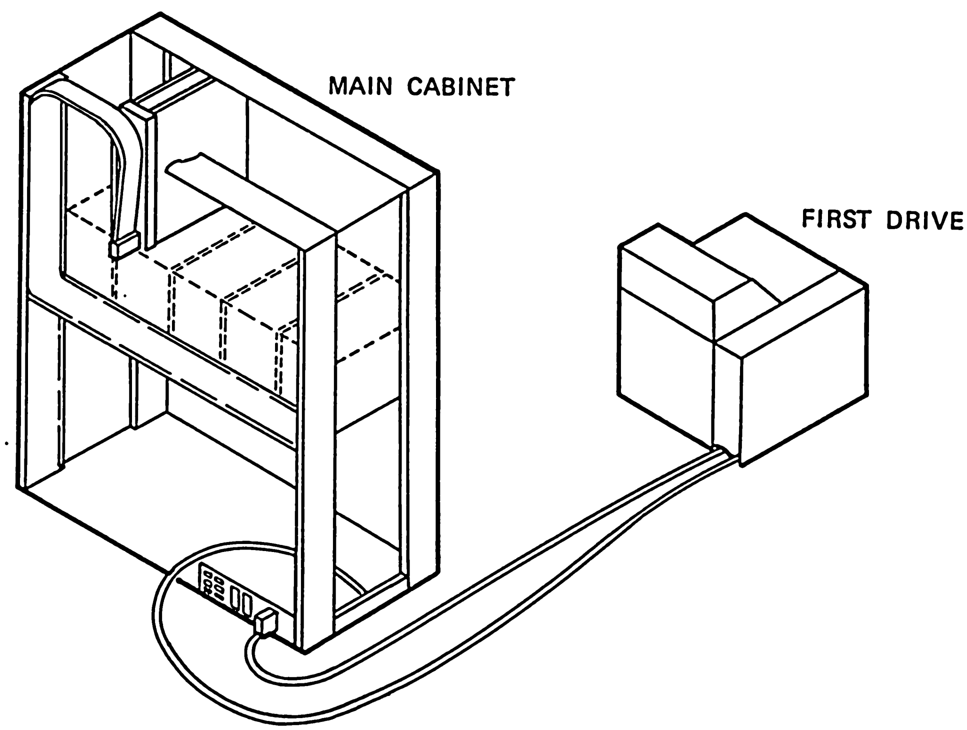
1. The first disk drive of daisy-chained drive complements is connected to the main frame by DEC 25 ft standard ground connector.

2. The second drive of the daisy chain is connected to the first drive by a 3 ft standard ground connector.

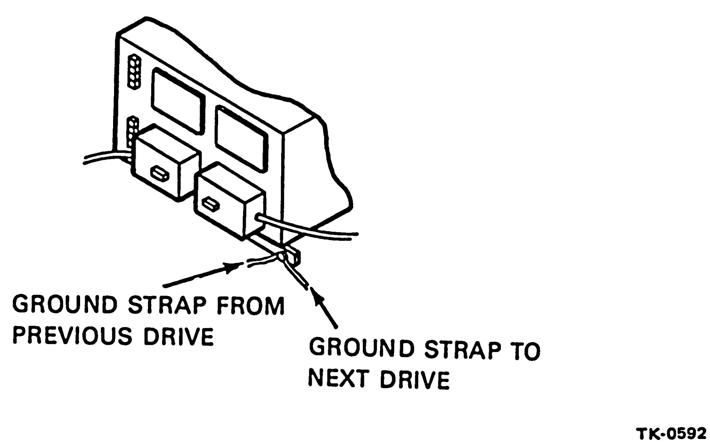
3. All subsequent drives of the daisy chain are similarly connected as in step 2.

Refer to Figure 3-58 for details.

The material in Appendix A extracted from the *DIGITAL Site Preparation Guide* is provided to show the importance of, and DIGITAL's basic approach to, the grounding of computer installations.



(A) MAIN CABINET TO FIRST DRIVE



(B) ALL DRIVES BETWEEN FIRST AND LAST

Figure 3-58 Grounding Details for RP05/06 Disk Drives

CHAPTER 4
H7100 DC POWER SUPPLY
FUNCTIONAL SECTION DESCRIPTIONS

4.1 GENERAL

Physically, the H7100 power supply comprises:

1. Frame
2. Front panel (ac input adapter)
3. Middle panel
4. Motherboard
5. Rear panel
6. Plug-in bias/control board
7. Two plug-in regulator boards (optional).

The system description of Chapter 3 covers these elements. The block diagram level discussion of Chapter 4 provides functional details of the motherboard, bias/control board, regulator boards, and the associated discrete components mounted on the middle panel and rear panel. Note that when the H7100 is installed, its motherboard is vertically oriented along the left side of the supply. The plug-in boards connect with the motherboard through jacks J1, J2, J3, and J4 (refer to the connector location diagram of Figure 4-1). The status board (described in Paragraph 3.4.3, Power-Failure Provisions in the H7100 DC Power Supply) connects to the sensing circuits on the bias control board via a ribbon cable (Figure 4-2). Figure 4-3 is the interconnection wiring diagram for the H7100.

In the system description (Chapter 3), the H7100 dc power supply was discussed under heading of its functional sections. Since the following block diagram description is keyed to the physical breakdown (front panel, middle panel, motherboard, rear panel, bias/control board and regulator boards) of the supply, a few points regarding their functional/physical relationships are in order.

First, consider the basic H7100 power supply with its single (+5.1 Vdc) output. Primary power from the single-phase input connector on the front panel reaches the raw dc supply (MB1) via connector P1/J8 at the top right corner of the middle panel (viewed from the front of the supply). Figure 4-1 shows the connector and the 7-point terminal board J6 on the motherboard supplying 120 or 240 Vac to the rectifier/filter components comprising the raw dc supply section. After the dc-to-ac inverter has converted the ±150 Vdc output of the raw dc supply to 20 kHz ac, the pulse output is fed to output transformer T1 on the rear panel. The rectifier, filter, snubber network, voltage sense, and current sense circuits are also located on the rear panel. The current and voltage sense outputs from the +5.1 Vdc output section are then fed to the +5 Vdc 100 A regulator circuits on the bias/control board (Figures 4-3 and 4-7). Details of regulator operation are given under Paragraph 4.6 (bias/control board).

The same transformer (T1) providing the 5.1 Vdc output provides the ac outputs for the F30 and +30 Vdc rectifiers and filters located on the motherboard.

The bias/control board carries the bias/control power supply, which generates regulated +12 and +5 Vdc as well as -12 Vdc unregulated for use by the power supply control circuits.

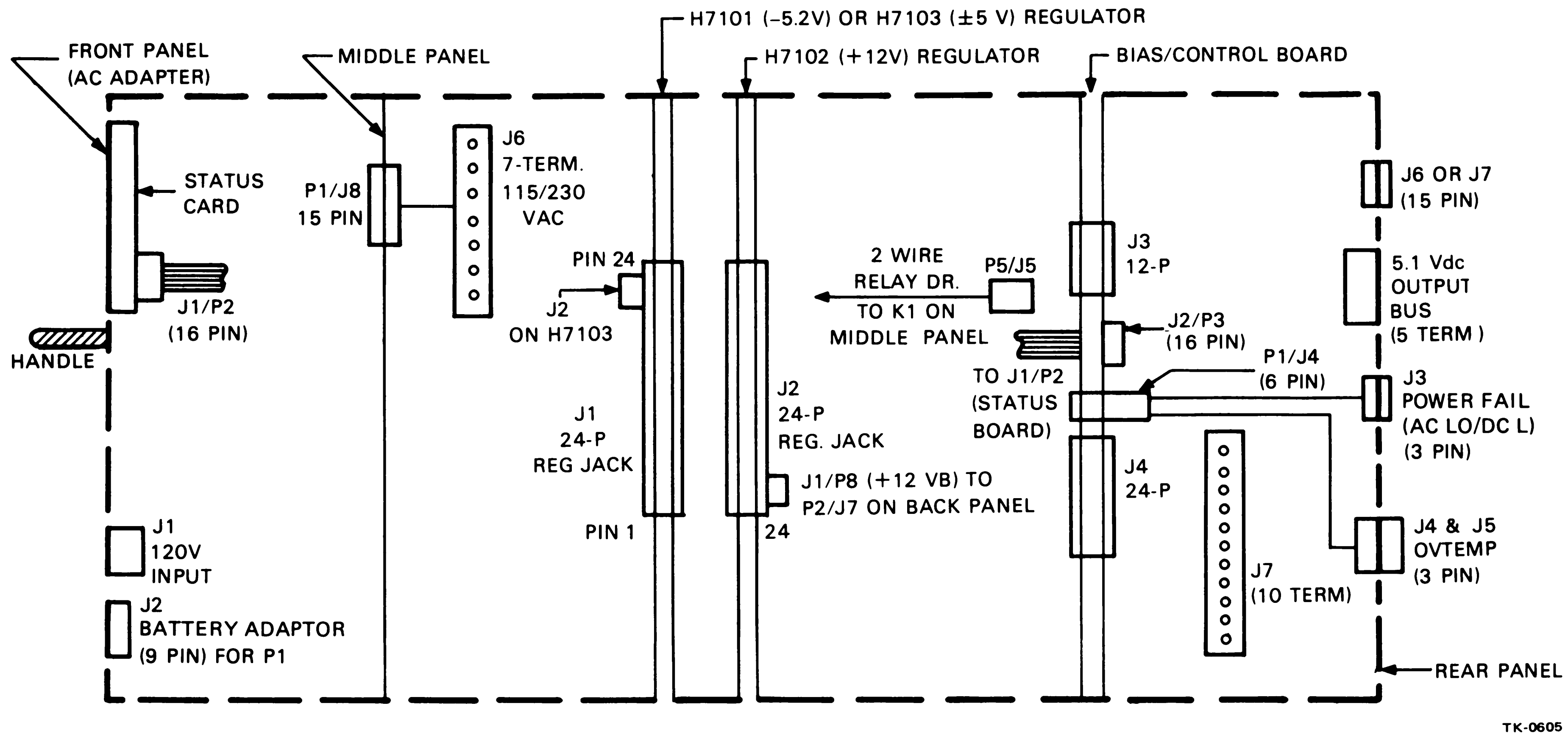


Figure 4-1 H7100 DC Power Supply – Connector Locations (Viewed from Right Side Looking Toward Motherboard)

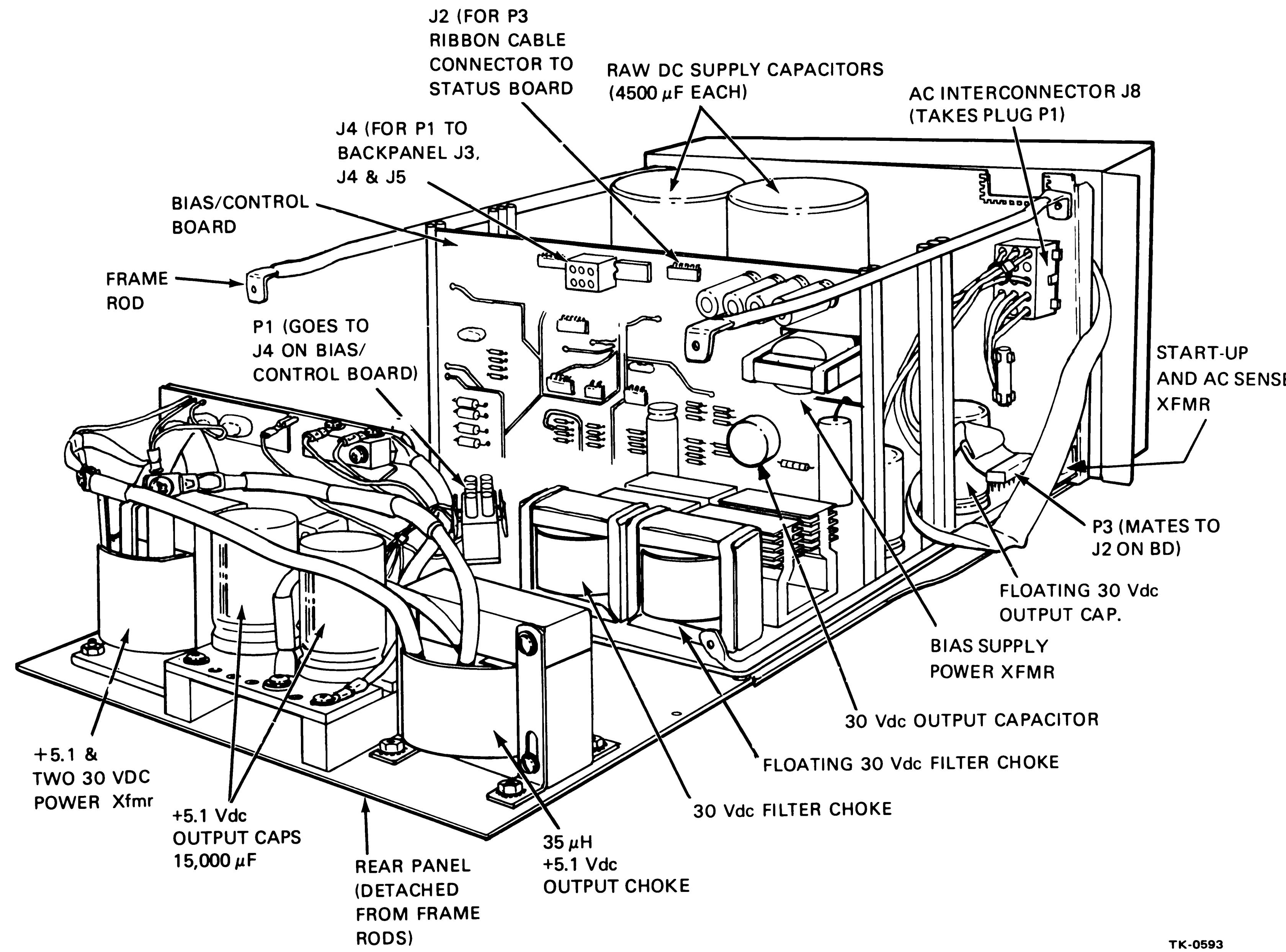


Figure 4-2 H7100 DC Power Supply – Component Identification

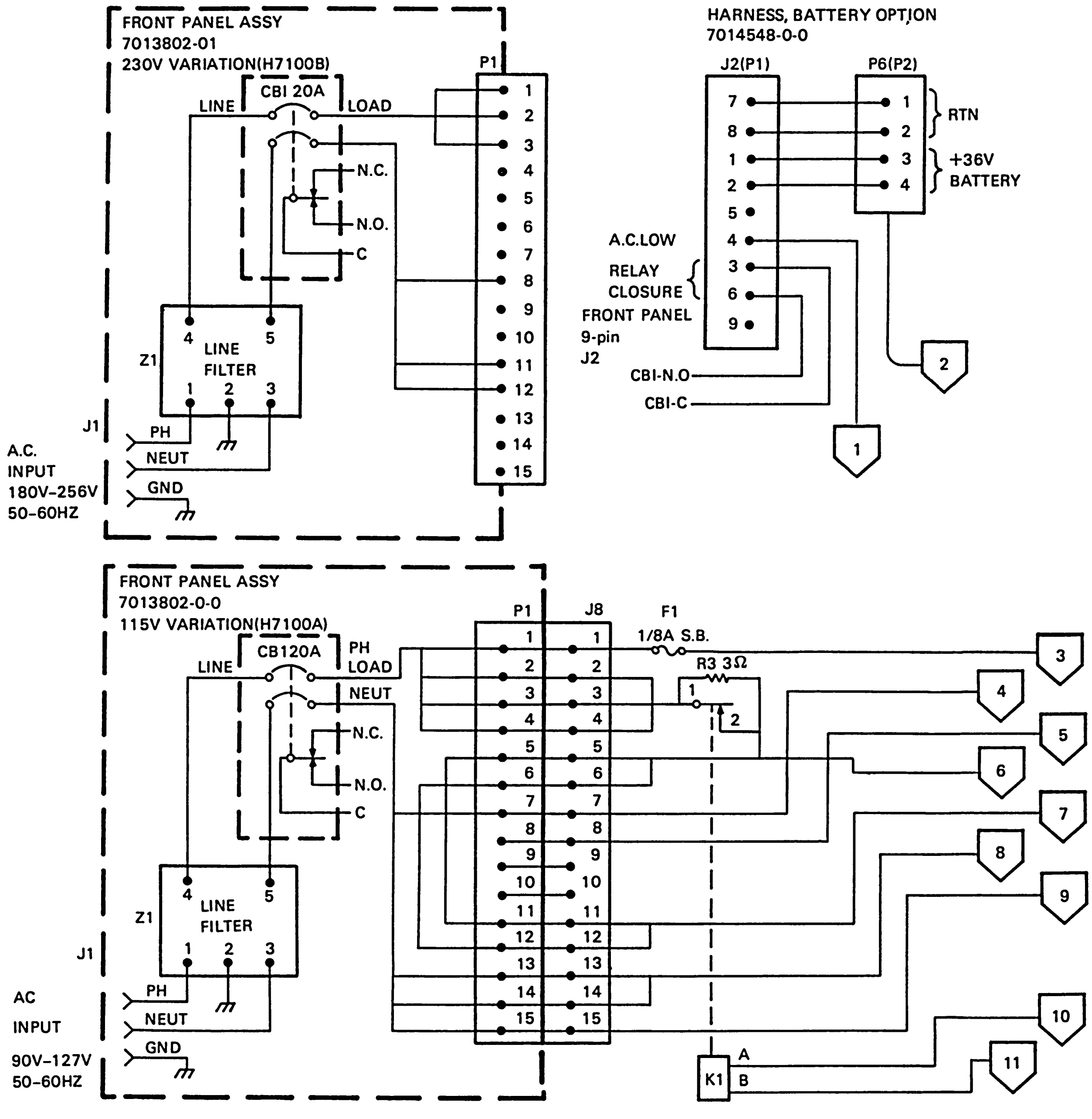


Figure 4-3 H7100 Power Supply Interconnection Diagram (Sheet 1 of 5)

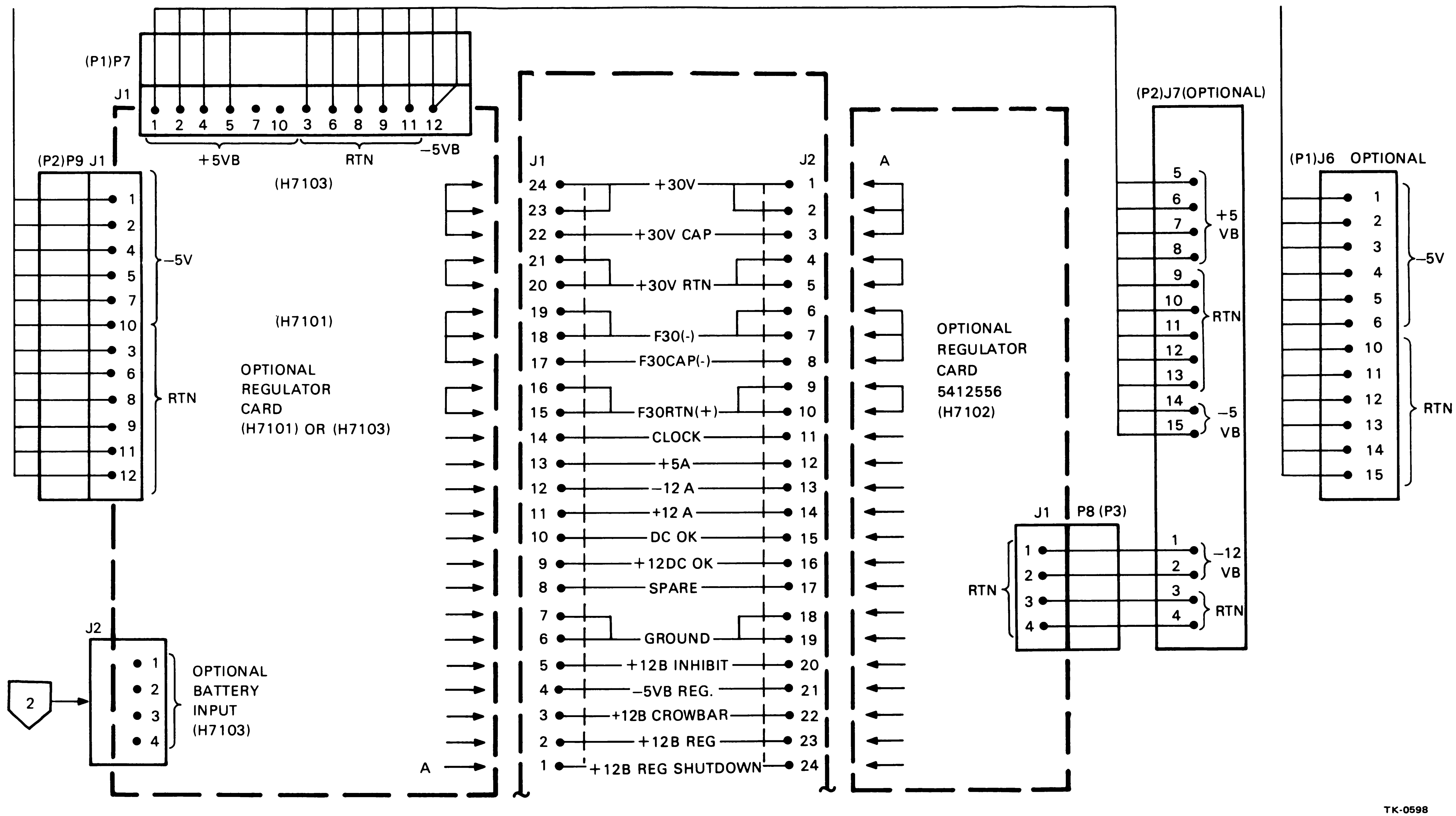


Figure 4-3 H7100 Power Supply
Interconnection Diagram (Sheet 2 of 5)

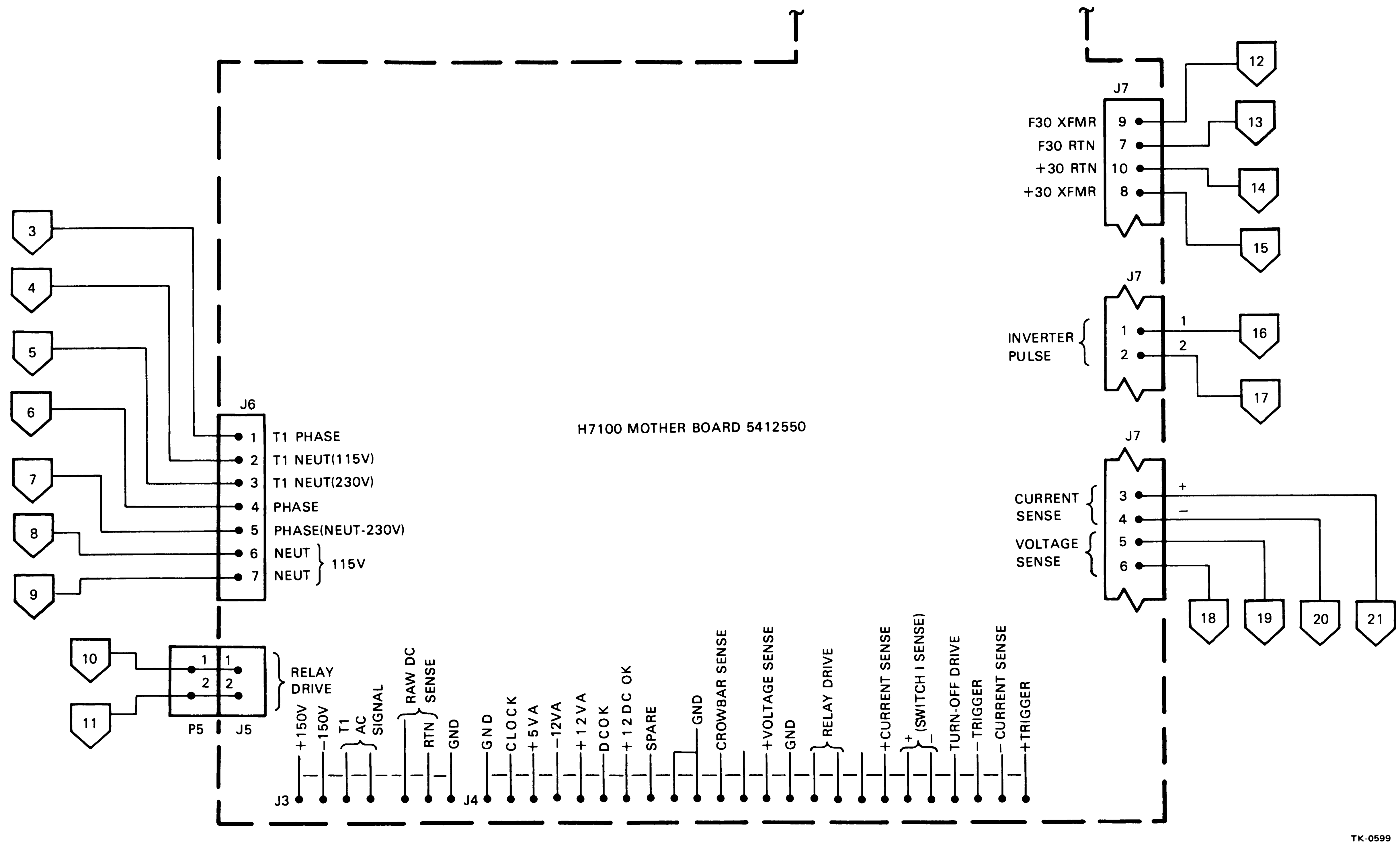


Figure 4-3 H7100 Power Supply Interconnection Diagram (Sheet 3 of 5)

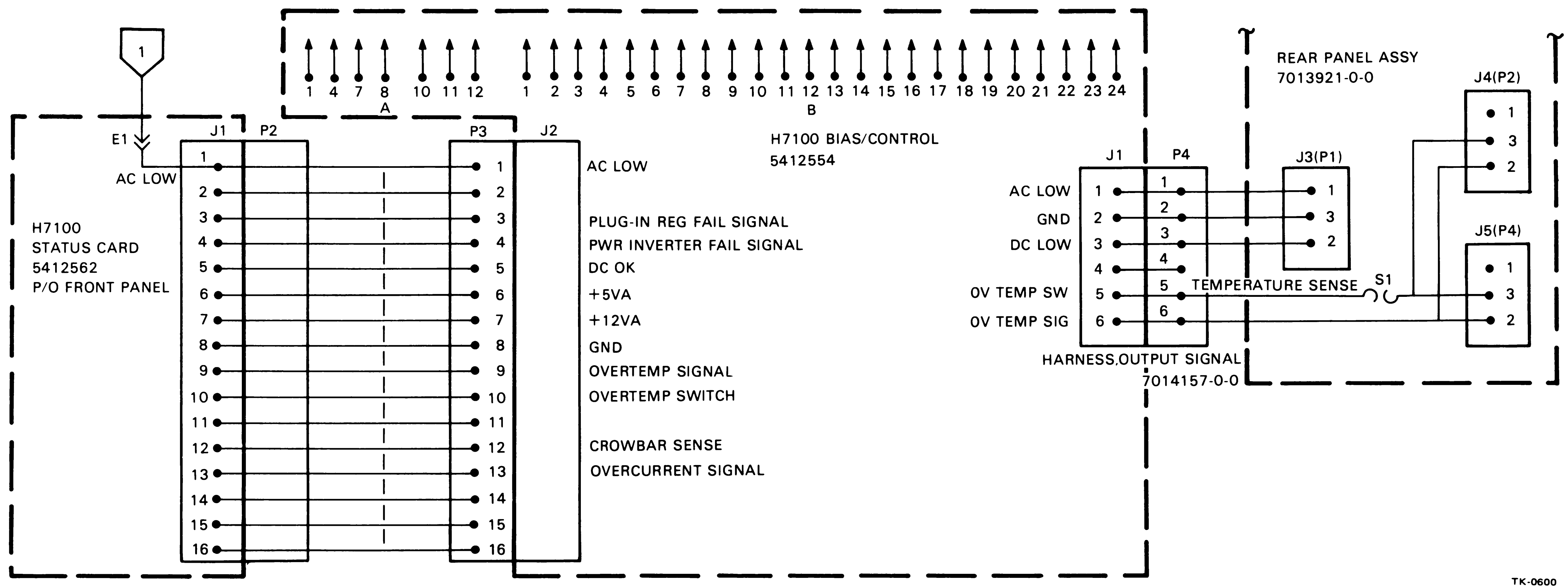


Figure 4-3 H7100 Power Supply Interconnection Diagram (Sheet 4 of 5)

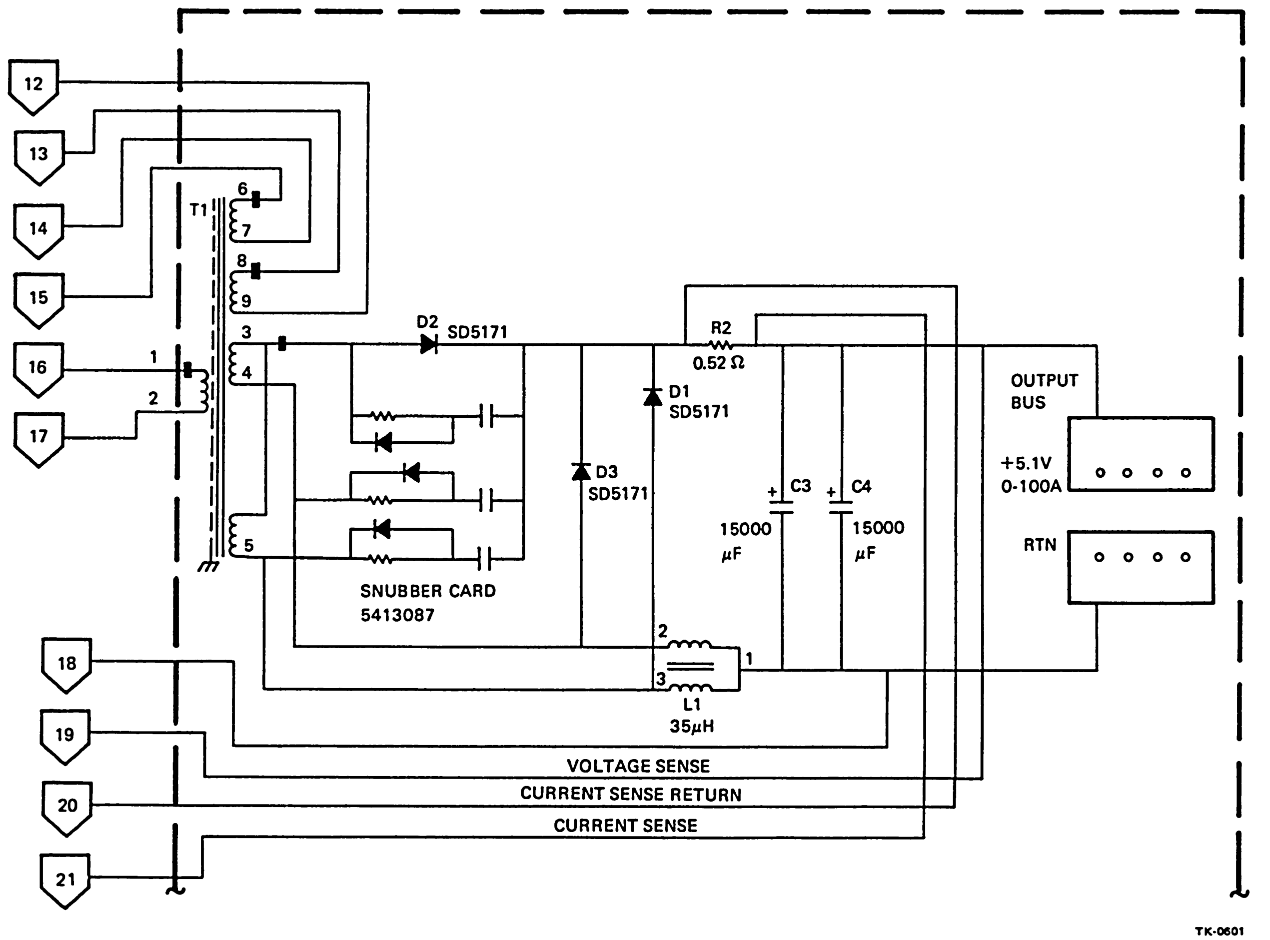


Figure 4-3 H7100 Power Supply Interconnection Diagram (Sheet 5 of 5)

The bias/control board also incorporates protection and status circuits (Figure 4-7). All status signals except AC LO energize the status indicators on the front panel. These signals leave the B/C board via connector P3/J2 (Figure 4-1).

As shown in Figure 4-1, the H7102 (+12 VB) regulator interfaces with the motherboard via 24-pin connector J2. Connector J1, which is parallel-wired with J2 (Figure 4-3) accepts either the H7101 (-5.2 Vdc) or H7103 (±5 VB) regulator board. The B designation indicates that the board has battery backup capability (Paragraph 4.7.1, H7103 Regulator).

4.2 FRONT PANEL (AC INPUT ADAPTER)

As seen in Figure 3-35, the front panel (ac input adapter) is comprised of the following.

1. AC input connector, J1
2. Battery adapter, J2
3. Single phase line filter
4. 2-pole, 20 A ac circuit breaker, CB1
5. Status card with ribbon connector J1/P2.

Figure 4-4 is a simplified block diagram showing the power flow from input connector J1, through the line filter and circuit breaker to connector P1/J8 located on the middle panel. Also shown is the AC LO line from the AC LO circuit (BC24) on the bias/control board. The function of this line is discussed in Paragraph 4.6 (bias/control board).

Two front-panel (ac input adapter) configurations are available for the H7100 – one for 120 Vac and one for 240 Vac controller outputs.

4.3 MIDDLE PANEL

Also shown in Figure 4-4 are the components mounted on the middle panel:

1. Connector P1/J8 (projects through the panel)
2. Fuse F1, a 1/8 A, slo-blo (on the panel backside)
3. Relay K1 (panel backside)
4. 3 ohm inrush limiting resistor (panel backside).

As shown in the interconnection diagram of Figure 4-3, primary power is provided to the motherboard raw dc supply via P1/J8. Relay K1 is energized by a 24 Vdc, 100 mA signal from relay driver BC32 on the bias/control board (refer to Paragraph 4.6).

4.4 MOTHERBOARD

The motherboard (refer to the block diagram of Figure 4-5) comprises the following circuits:

1. Start-up and ac sense transformer
2. Raw dc supply
3. Power switch and base drive transformer
4. Snubber networks
5. Reset diodes
6. Raw dc sense
7. Crowbar
8. +30 Vdc rectifier/filter section
9. Floating 30 Vdc rectifier/filter section.

4.4.1 Start-Up and AC Sense Transformer

This transformer steps down the 120 or 240 Vac to 12 Vac for use in power supply start-up and for ac line monitoring after start-up.

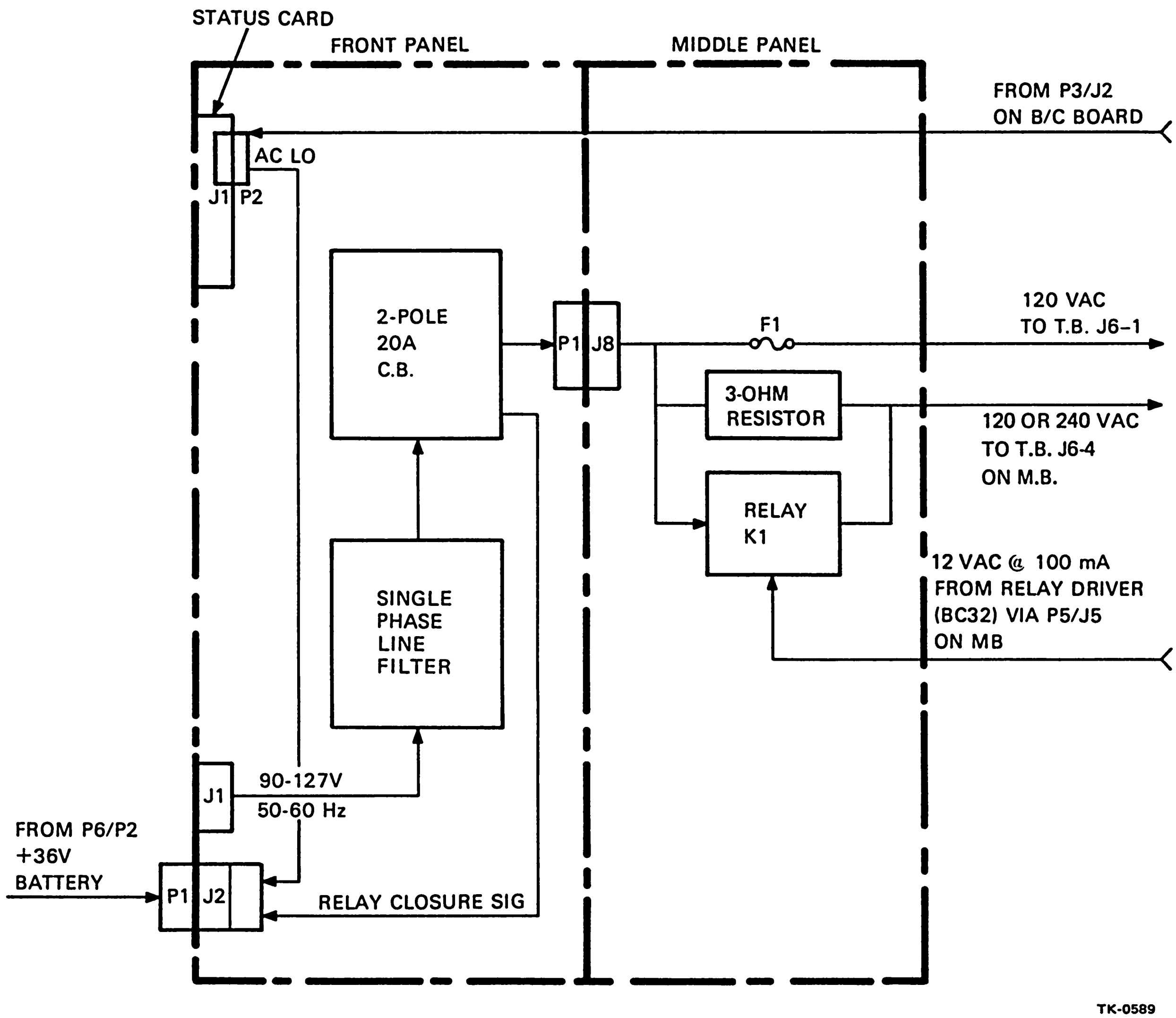


Figure 4-4 H7100 Front Panel/Middle Panel Block Diagram

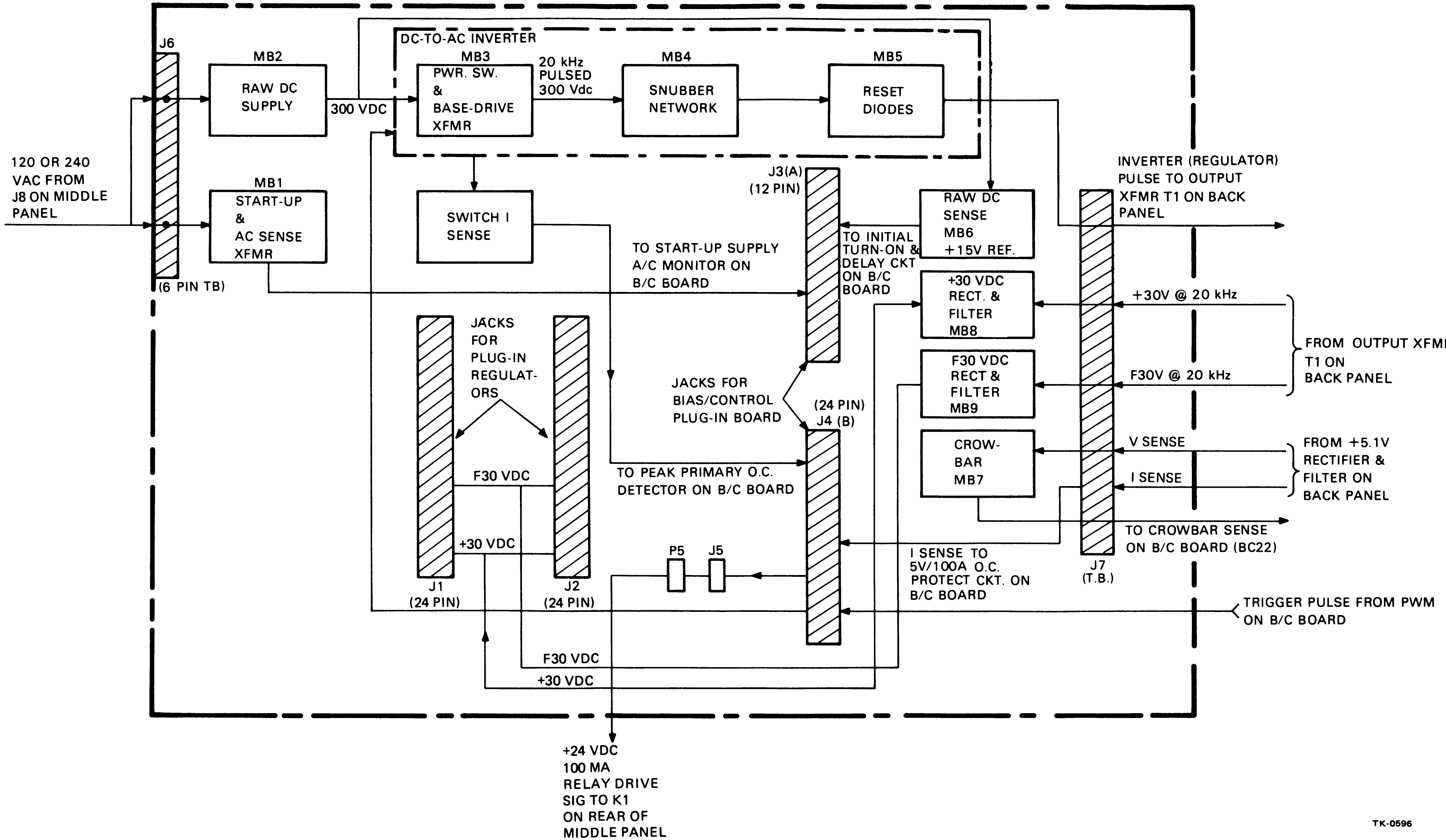


Figure 4-5 H7100 Motherboard Block Diagram

4.4.2 Raw DC Supply
The raw dc supply is the source of the ±150 Vdc used by the inverter. With 120 Vac input, the raw dc supply functions as a voltage doubling rectifier; with a 240 Vac line, the supply is connected as a fullwave rectifier. Large (4500 μF) capacitors provide storage for powerline ride-through.

4.4.3 Power Switch and Base Drive Transformer
The power switch controls the main flow of power through the power supply by delivering a variable-width pulse to the power transformer. Four transistors, all turned on (or off) simultaneously, connect the power transformer to the dc source during the pulse. Base drive is achieved by means of a second transformer, whose inductive energy triggers on the bases of the four transistors. Emitter currents in two of these transistors couple more base drive energy through this transformer for the remainder of the pulse. Four fusible link resistors protect the transformer against overload.

4.4.4 Snubber Networks
Two identical snubber networks, each consisting of a capacitor in series with a parallel resistor/diode combination, divert inductive current from each of the two pairs of power transistors during turn-off.

4.4.5 Reset Diodes
The reset diodes provide a path for the inductive current stored in the power transformer after the power switch has turned off. The inductively stored current forces the polarity of the transformer to reverse until all the stored energy is returned to the raw dc supply. Polarity reversal time is equal to pulse time.

4.4.6 Raw DC Sense
The raw dc sense circuit measures the raw dc (±150 V) and compares it to a reference voltage. When the raw dc increases to 225 Vdc, a low signal is produced at J3 to turn on the power supply. When the raw dc decreases to 175 V, this signal goes high and the power supply is turned off. This circuit floats at a −150 Vdc level. A resistor/diode combination provides the +15 Vdc required for operation of the raw dc sense circuit.

4.4.7 Crowbar
The crowbar provides a short circuit across the +5 Vdc output whenever this output exceeds 6.3 Vdc. A sense signal is provided to the crowbar detector (BC22) on the B/C board to shut off the power supply when the crowbar fires.

4.4.8 +30 Vdc Section
In the +30 Vdc circuit a power pulse from the power transformer is LC-filtered to 30 Vdc nominal. Under no-load conditions, a resistor holds this voltage below 50 Vdc. When either regulator card is plugged in, the filter capacitor is automatically connected. The +30 Vdc negative return is tied to the +5 Vdc return.

4.4.9 Floating 30 Vdc Section
The floating 30 Vdc section operates in the same way as the +30 Vdc section, but is wired as a negative output. Since neither output is referenced to ground, this section can be used for either positive or negative regulators.

4.5 REAR PANEL
Figure 4-6 is a block diagram of the circuitry on the rear panel of the H7100. The principal component on the rear panel is the output transformer, T1. When energized by the 300 V (peak) 20 kHz pulse train from the dc-to-ac inverter on the motherboard, this transformer provides low voltage outputs for the +5.1 Vdc rectifier and filter located on the back panel, and for the two 30 V rectifier/filter sections located on the motherboard.

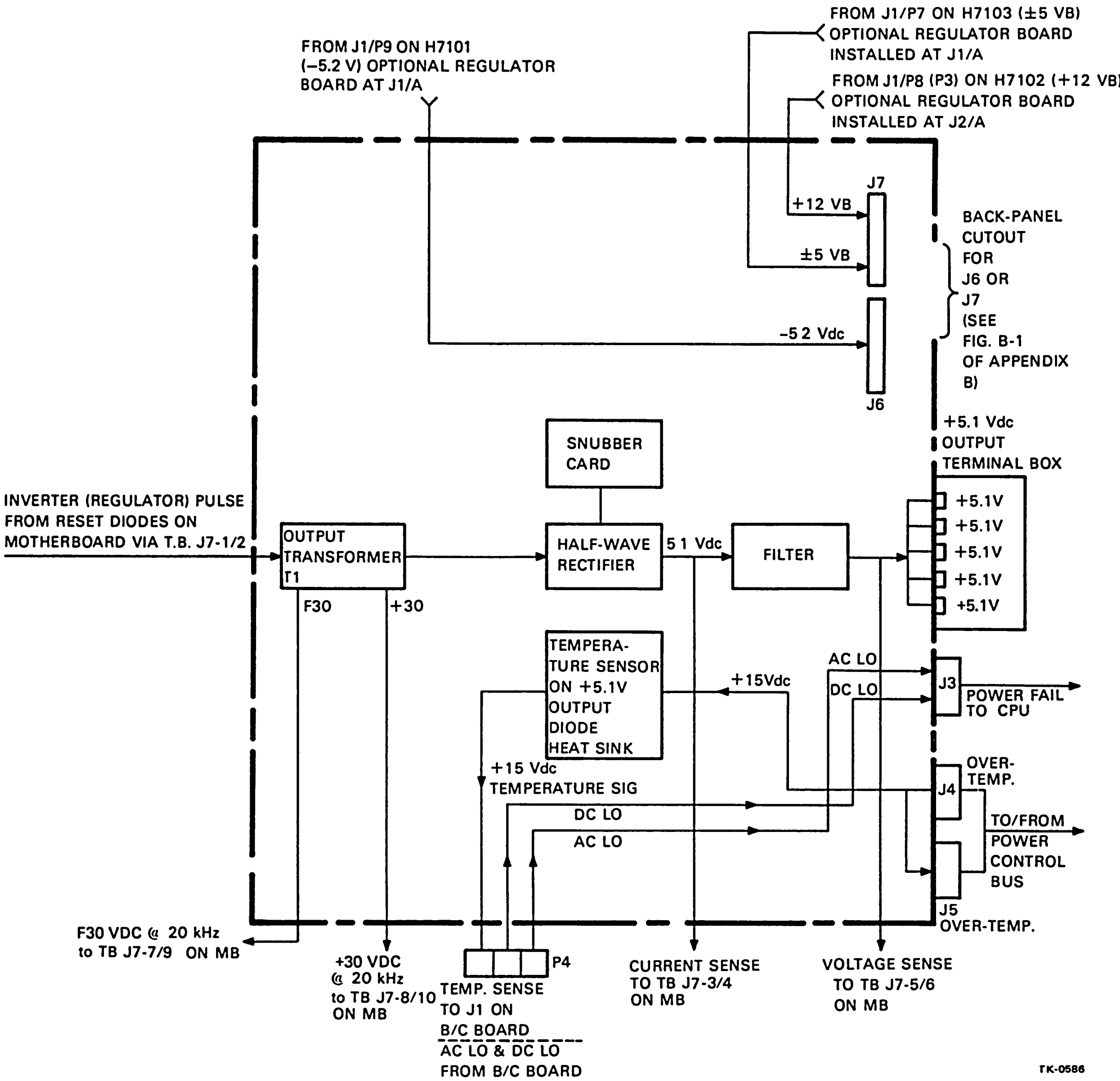


Figure 4-6 H7100 Rear Panel Block Diagram

The temperature sensor (located on the +5.1 Vdc output diode heat sink mounted below output transformer T1 on the back panel) receives +15 Vdc from line 2 of the DEC power control bus. When the design temperature of 100° C (212° F) for sensor closure is reached, emergency shutdown is generated on the power control bus when sensor closure grounds the +15 Vdc overtemperature signal.

As seen in Figure 4-6, the AC LO and DC LO signals from corresponding circuits (BC24 and BC25) on the bias/control board are fed to the CPU through backpanel connector J3 for use in power-fail sequencing.

Connectors J6 and J7 are never used together. Connector J6 is used with the H7101 (–5.2 Vdc) regulator board, and J7 with the paired battery backup boards, H7102 (+12 VB) and H7103 (±5 VB). The connector used is inserted in a backpanel rectangular cutout (Figure 3-31). Figure B-1 shows the cabling configuration from regulator boards to output connector, and the connection to the battery backup power supply used with the H7102/H7103 board combination.

The +5.1 Vdc, 100 A output is parallel-wired to 5 positive (red) output terminals and 5 negative (black) return terminals. The back of the output connector box provides the mounting surface for the two 15,000 μf output capacitors of the +5.1 Vdc supply.

4.6 BIAS/CONTROL BOARD

The circuits on the bias/control board can be functionally divided into three principal elements (refer to the block diagram of Figure 4-7).

1. Bias/control power supply
2. 5.1 Vdc, 100 A regulator circuitry
3. Protection and status circuits.

The 5.1 Vdc, 100 A regulator was functionally described in Paragraph 3.3.2 (power generation – H7100 dc power supply). Paragraph 4.6.1 describes the functional composition of the basic H7100 regulator.

The bias/control power supply section of the bias/control board provides regulated +5 Vdc and +12 Vdc as well as unregulated –12 Vdc for the H7100 control circuits and LEDs.

As the name implies, the protection circuits (e.g., I sense, crowbar sense, etc.) generate signals that protect the supply from destructive malfunctions, but do not provide visual indications of the condition. The status circuits provide front-panel indications of power supply status (Paragraph 3.4.3 – power-failure provisions in the H7100 dc power supply).

4.6.1 Bias/Control Power Supply

The bias/control power supply (Figure 4-7) comprises:

1. Snubber-suppressor (BC1)
2. Bias power switch (BC2)
3. ±12 V bias supply (BC3)
4. +5 V bias regulator (BC4)
5. Bias power switch driver (BC5)
6. Bias control amplifier (BC6)
7. Bias ramp generator (BC7)
8. 20 kHz bias clock (BC8)
9. Bias pulse width modulator (BC9)
10. Start-up supply and ac monitor (BC10).

4.6.1.1 Snubber-Suppressor (BC1) – The snubber-suppressor protects the single-transistor bias power switch (BC2) during turn-off by diverting inductive currents away from the transistor and limiting the maximum voltage caused by any ringing to a safe value.

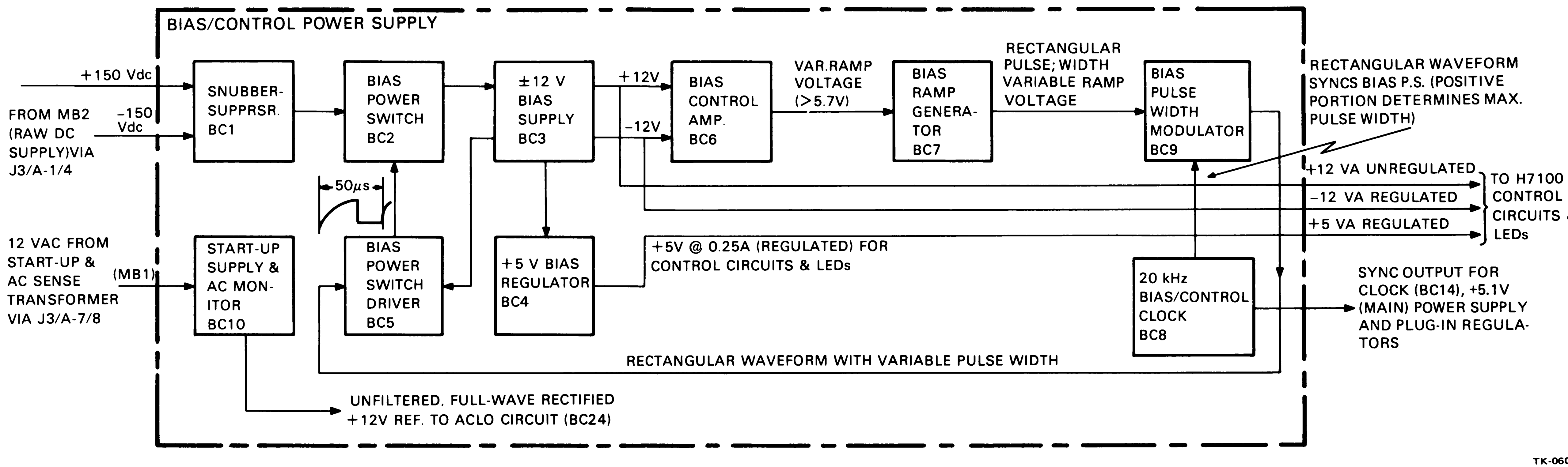


Figure 4-7 H7100 Bias/Control Board Block Diagram (Sheet 1 of 3)

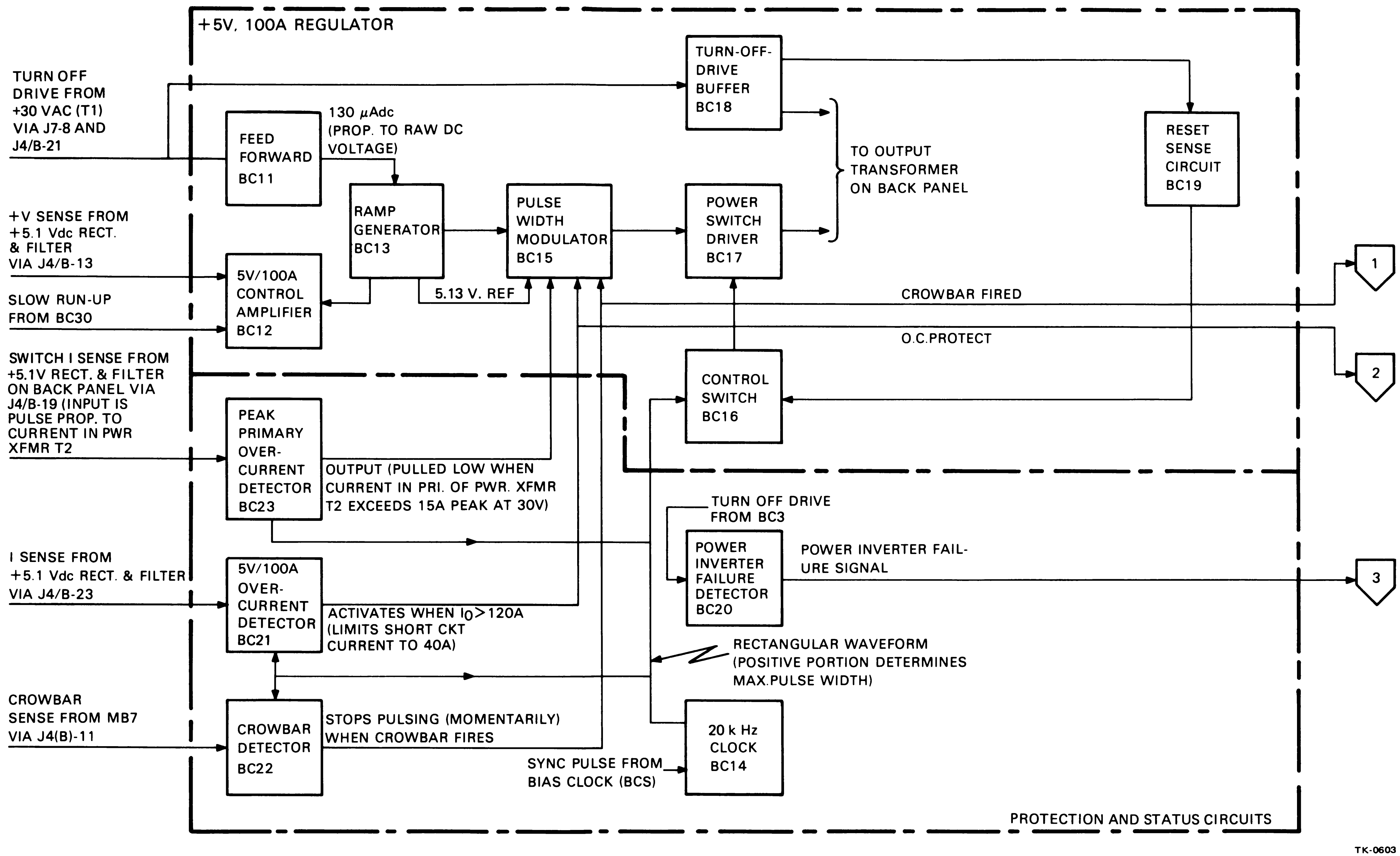


Figure 4-7 H7100 Bias/Control Board Block Diagram (Sheet 2 of 3)

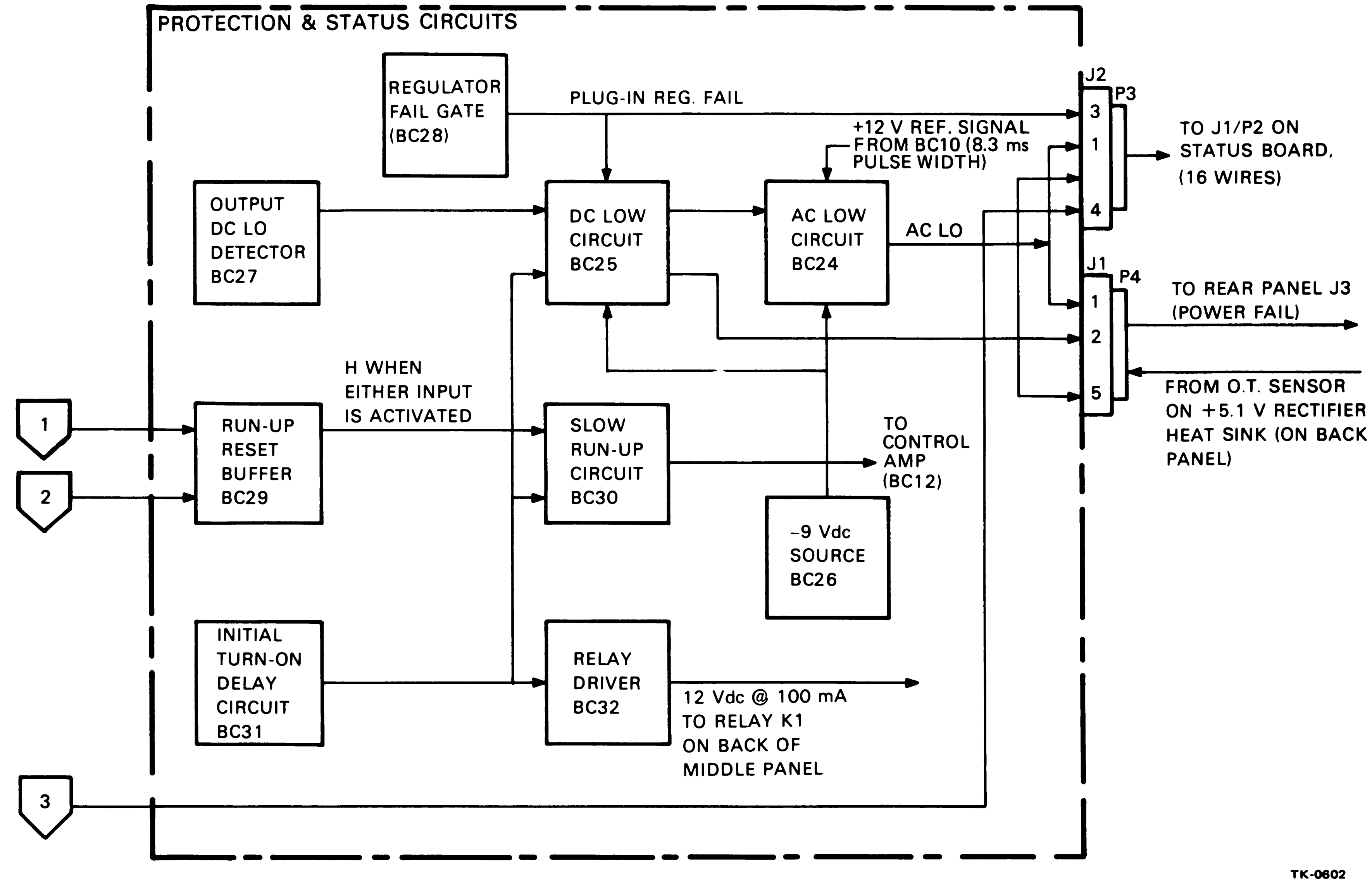


Figure 4-7 H7100 Bias/Control Board Block Diagram (Sheet 3 of 3)

4.6.1.2 Bias Power Switch (BC2) – The bias power switch controls the main power flow into the ±12 V bias power supply by changing the inductance of the flyback transformer's primary winding.

4.6.1.3 ±12 V Bias Supply (BC3) – The ±12 V bias supply is the basic source of the voltages (+12, −12, and +5) required for H7100 control and for its LED indicators. When the transistor switch for bias power (BC2) is off, two diodes (one in each leg of the flyback transformer's secondary) discharge the transformer-stored energy into the output capacitors and loads. These diodes are reverse biased when the transistor switch is on and the flyback transformer is charging. Signals for drive turn-off and transistor-switch hold-off are provided for the power switch driver (BC5).

4.6.1.4 5 V Bias Regulator – An LM340T-5 3-terminal regulator uses the +12 V output from the bias supply to produce +5 V at 0.25 A for the H7100 internal logic circuits and LEDs.

4.6.1.5 Power Switch Driver (BC5) – The power switch driver is energized by a variable-width pulse from the bias supply pulse width modulator (PWM) (BC9) and drives the bias power switch transistor through the power switch driver transformer. When the driver switch transistor is off, the bias power switch transistor (BC1) is triggered by the inductive energy stored in the driver transformer and driven by the current through its secondary windings. When the driver switch transistor is driven on, the bias power switch transistor is turned off. A forward-biased diode holds the driver switch transistor on until the energy in the flyback transformer of BC3 is depleted.

4.6.1.6 Bias Ramp Generator (BC7) – The bias ramp generator accepts a variable ramp voltage (above 5.7 V) and produces a ramp waveform of fixed amplitude and variable ramp time. The precision reference for comparison with the input ramp voltage is also generated here.

4.6.1.7 Bias Clock (BC8) – The bias clock produces a 20 kHz rectangular waveform that establishes a maximum pulse width. This signal synchronizes the bias supply and provides a clock output to sync the main +5.1 V supply and the plug-in regulators.

4.6.1.8 Bias Pulse Width Modulator (BC9) – The bias pulse width modulator accepts 20 kHz clock pulses from BC8 and a variable width ramp input from the ramp generator (BC7) to produce a rectangular waveform with variable pulse width to drive the power switch (BC2).

4.6.1.9 Start-Up Supply/AC Monitor (BC10) – During initial power up of the H7100, 12 Vac from the start-up transformer is rectified by the start-up supply/ac monitor circuit to produce +11 Vdc. This voltage energizes all of the bias supply circuits and pulses the transistor switch of the power switch (BC2) to power up the 12 VA flyback power supply. When the output of this supply reaches 10.5 V, normal operation is possible and the ac input to the start-up supply/ac monitor is unloaded. The unfiltered, rectified ac waveform is used to measure line voltage to determine AC LO at BC24.

4.6.2 +5.1 V, 100 A Regulator

The +5.1 V, 100 A (main) regulator comprises (Figure 4-7):

1. The feed-forward circuit (BC11)
2. +5.1 V/100 A control amplifier (BC12)
3. Ramp generator (BC13)
4. 20 kHz clock (BC14)
5. Pulse width modulator (BC15)
6. Control switch (BC16)
7. Power switch driver (BC17)
8. Turn-off-drive buffer (BC18)
9. Reset sense circuit (BC19)
10. Power-switch fail detector (BC20)
11. 5 V/100 A overcurrent detector (BC21)
12. Crowbar detector (BC22)
13. Peak primary overcurrent detector (BC23).

4.6.2.1 Feed-Forward Circuit (BC11) – The feed-forward circuit peak-detects the 150 V (nominal) pulses from the power transformer (T1) on the rear panel. This input, referred to as "turn off drive" originates at one leg of the 30 V winding. Since the detected peaks are proportional to line voltage, the output is a dc current proportional to line voltage; e.g., at 120 Vac this current is 130 μA.

4.6.2.2 5 V/100 A Control Amplifier (BC12) – The 5 V/100 A control amplifier compares the +5.1 V output (nominal) of the.H7100 supply with a precision reference generated by the ramp generator section (BC13) and a voltage from the slow run-up circuit (BC30). R/C feedback circuits control the frequency response of the regulator loop. When the feedback signal (from the ramp generator) is negative, the power supply is off. The output of the control amplifier is a current whose magnitude depends upon a combination of line and load conditions.

4.6.2.3 Ramp Generator (BC13) – The ramp generator accepts variable-current inputs from the feed-forward (BC11) and control amplifier (BC12) circuits, adds them, and produces a ramp waveform of fixed amplitude and variable ramp time. This section also includes the circuit for the 5.130 V reference that determines the output voltage.

4.6.2.4 20 kHz Clock (BC14) – The 20 kHz clock produces a rectangular waveform whose positive portion determines the maximum pulse width for the power stage. A signal from the bias/control clock (BC8) synchronizes the two clocks.

4.6.2.5 Pulse Width Modulator (BC15) – The pulse width modulator synchronizes ramp generator output with the negative edge of the clock pulse waveform to produce a rectangular waveform whose pulse width is equal to the ramp time. Inputs to the NE555 timer of the PWM circuit from the crowbar sense or switch I sense will cause pulsing to cease under overvoltage or overcurrent conditions.

4.6.2.6 Control Switch (BC16) – The control switch provides a positive output when the clock signal is low, when a low is received from the reset sense circuit (BC19), and during turn-on from the start-up/ac monitor (BC10).

4.6.2.7 Power Switch Driver (BC17) – The power switch driver amplifies the pulsed signal from the PWM and control switch and drives the main power inverter. When the transistor switch controlling the drive to the main power inverter is on, the power switches are off. When this switch is turned off, energy in the transformer of the power switch (MB3) triggers the power stage and it turns on.

4.6.2.8 Turn-Off-Drive Buffer (BC18) – The turn-off-drive buffer responds to a 150 V pulse from one leg of the 30 V winding of the power output transformer on the rear panel by storing energy in a capacitor. This energy provides a source of power for fast turn-off of the power switches. After capacitor discharge, current through a resistor provides energy storage in the transformer of the power switch (MB3) to retrigger the power switches.

4.6.2.9 Reset Sense Circuit (BC19) – The reset sense circuit detects the negative portion of the turn-off-drive pulse from the 30 V winding of the output transformer when the power switches are off and the transformer is reverse-biased and resetting. During reset, the switches are held off by the control switch (BC16) through a connection to the start-up supply/ac monitor circuit (BC10).

4.6.2.10 Power-Switch-Fail Detector (BC20) – The power-switch-fail detector provides a logic low to the status card whenever the power switches of MB3 are driven on and no pulse is issued from the power transformer, a condition that only happens when the power switches are not working. This failure condition is indicated by the red "power inverter failure" indicator on the H7100 front panel.

4.6.2.11 5 V/100 A Overcurrent Detector (BC21) – The 5 V/100 A overcurrent detector accepts a 50 mV/100 A voltage proportional to the 5 V load current, compares this voltage to a threshold reference and produces an overcurrent signal (negative edge) when the threshold is exceeded. The threshold is approximately 60 mV (120 A) with the output at 5 V, and 30 mV (60 A) with the output at 0 V (short circuit).

4.6.2.12 Crowbar Detector (BC22) – The crowbar detector is a diode that isolates the timing circuit from the crowbar circuit (MB7). When the crowbar fires, the crowbar detector is pulled low (to 1 V).

4.6.2.13 Peak Primary Overcurrent Detector – The peak primary overcurrent detector receives a pulse (from the switch I sense transformer T3 on the motherboard) that is proportional to the current in the power transformer (T2 on the motherboard) primary. The detector compares this signal with a reference and pulls detector output low when the 30 V (15 A peak) reference is exceeded.

4.6.3 Protection and Status Circuits

The protection and status circuits (Figure 4-7) comprise:

1. AC LO circuit (BC24)
2. DC LO circuit (BC25)
3. –9 Vdc source (BC26)
4. Output DC LO detector (BC27)
5. Regulator-fail gate (BC28)
6. Run-up reset buffer (BC29)
7. Slow run-up circuit (BC30)
8. Initial turn-on and delay circuit (BC31)
9. Relay driver (BC32).

4.6.3.1 AC LO (BC24) – The AC LO circuit accepts unfiltered full-wave-rectified ac from the start-up supply/ac monitor (BC10). An LM301 op amp in the AC LO circuit compares the ac peaks to a reference from the ramp generator BC13) of the +5.1 V, 100 A regulator and produces a train of pulses at twice the power line frequency. When the ac peaks are above the reference level (90 Vac input), op amp output to a 9601, 15 ms delay, 1-shot multivibrator stretches the pulse train to a dc level that turns the AC LO output transistor off, causing AC LO to go to –9 V (i.e., AC LO is deasserted).

4.6.3.2 DC LO (BC25) – When all three logic inputs to the DC LO circuit are low, a logic high is produced for the status card and the AC LO output transistor turns off, allowing –9 V at DC LO (DC LO deasserted). The three logic inputs to the DC LO circuit are the output DC LO detector (BC27), regulator-fail gate (BC28) and initial turn-on and delay (BC31).

4.6.3.3 –9 Vdc Source (BC26) – The zener regulator of the –9 Vdc source circuit provides the –9 Vdc for AC LO and DC LO outputs.

4.6.3.4 Output DC LO Detector (BC27) – The output DC LO detector is an LM339 comparator that provides a low output whenever the 5 Vdc bus rises above 4.75 Vdc.

4.6.3.5 Regulator-Fail Gate (BC28) – The regulator-fail gate produces a logic high when the +12 Vdc OK input is pulled low, indicating a failed plug-in regulator card. The logic high output of BC28 is supplied to the DC LO circuit (BC25) and the status card (via J2/P3) on the bias/control board, the ribbon cable, and J1/P2 on the status board.

4.6.3.6 Run-Up Reset Buffer (BC29) – The run-up reset buffer produces a logic high that initiates slow run-up through BC30 and the 5 V/100 A control amplifier (BC12) if the crowbar (MB7) fires or the peak primary overcurrent detector (BC21) is activated.

4.6.3.7 Slow Run-Up Circuit (BC30) – The slow run-up circuit accepts logic signals from the run-up reset buffer (BC29) and the initial turn-on and delay circuit (BC31). With either input high, the output diode of the slow run-up circuit is held negative. When both inputs are low, a capacitor charges slowly until the slow-run-up output diode is reverse-biased, allowing the precision reference voltage to determine output voltage.

4.6.3.8 Initial Turn-On and Delay Circuit (BC31) – The initial turn-on and delay circuit accepts a low signal from the raw-dc sense circuit (MB6) and produces a logic low output after a delay of approximately 100 ms.

4.6.3.9 Relay Driver (BC32) – The relay driver accepts a logic low from the initial turn-on and delay circuit and produces +12 Vdc at 100 mA to drive the inrush relay (K1) whose other terminal is a –12 Vdc. Closure of the relay shorts out the 3 ohm inrush resistor located adjacent to the relay on the back of the middle panel.

4.7 REGULATOR OPTIONS

The regulator options for the H7100 dc power supply are:

1. H7101 – –5.2 V at 30 A (54-12560)
2. H7102 – +12 VB* at 10 A (54-12556)
3. H7103 – ±5 VB (+5 VB at 20 A; –5 VB at 0.2 A) (54-12558).

The H7101, H7102 and the +5 VB section of the H7103 use the switching regulator concept described in Paragraph 3.3.2.1. Because of its low (200 mA) load current requirement, the –5 VB regulator of the H7103 is a switching polarity inverter used in conjunction with a 3-terminal output regulator.

4.7.1 H7101 (–5.2 V) Regulator

As seen from the block diagram of Figure 4-8, the H7101 comprises:

1. Base drive circuit
2. Power switch
3. Output filter
4. Overcurrent circuit
5. Error amplifier
6. Ramp generator
7. Pulse width modulator (PWM)
8. 20 kHz clock
9. Turn-off-drive circuit
10. Flyback diode
11. DC OK circuit
12. Crowbar
13. Voltage reference
14. Slow run-up circuit.

4.7.1.1 Base Drive Circuit – The base drive circuit consists of a pulse transformer and base drive transistor whose input is controlled by the duty cycle control signal from the pulse width modulator. Power for the H7101 regulator is unregulated –30 V from the 350 μh choke of the floating 30 V supply on the motherboard. Line protection is provided by a 15 A fuse at the input to the pulse transformer secondary. A 1,000 μF filter capacitor is automatically connected to the 30 V source when the regulator is plugged into jack J1 (Figure 4-1). Sensing of pulse transformer input for the turn-off-drive circuit of the H7101 regulator is accomplished at the primary of the pulse transformer.

4.7.1.2 Power Switch – The power switch consists of a balun transfomer and two power transistors that are switched by the pulse transformer output of the base drive circuit. The balun divides the current equally between the two transistors.

4.7.1.3 Output Filter – The output filter consists of a 25 μh choke and 15,000 μF capacitor.

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*The "B" suffix indicates a battery backup capability.

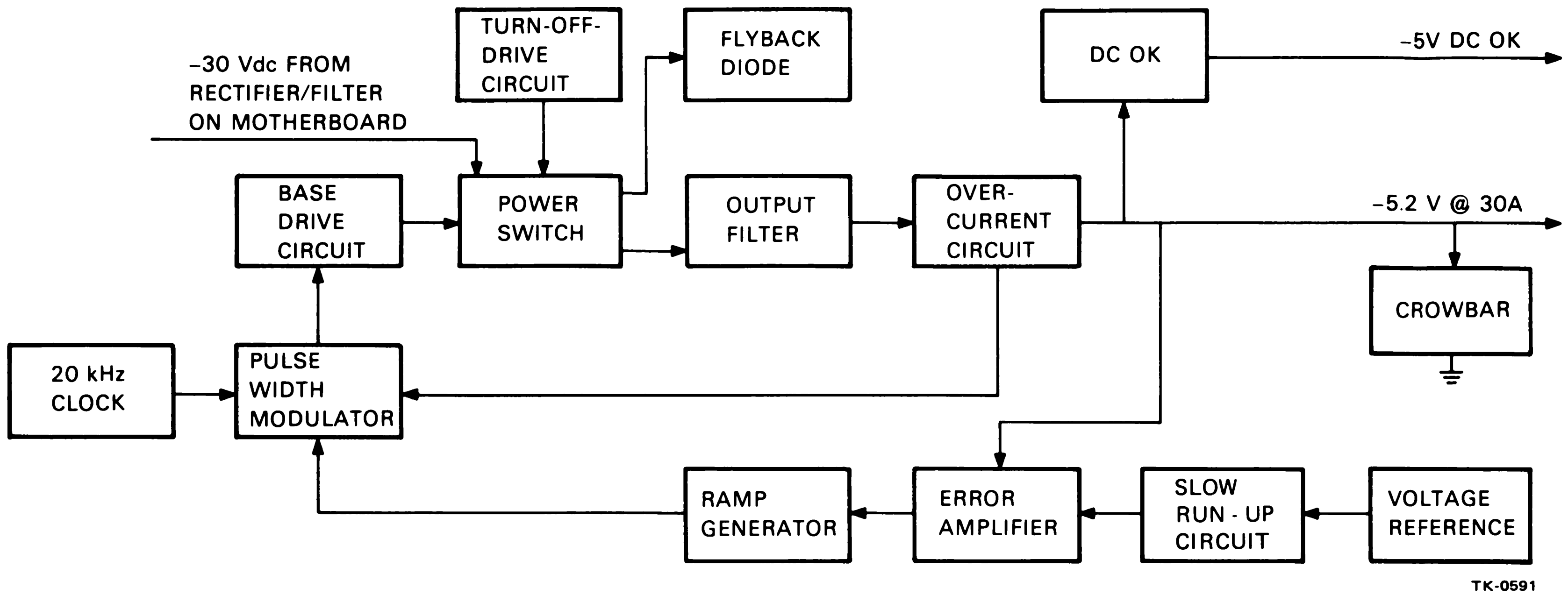

Figure 4-8 H7101 (–5.2 V at 30 A)
Regulator Block Diagram

4.7.1.4 **Overcurrent Circuit** – Current limiting in the overcurrent circuit is provided by two paralleled resistors in series with the 25 μH choke of the output filter. This arrangement permits monitoring of peak choke current (approximately 40 A peak-to-peak). The current through the two paralleled resistors and the voltage across them is triangular in shape and rides on the average dc output current. The current limit for the -5.2 V output is set at 36 A.

4.7.1.5 **Error Amplifier** – In the error amplifier, an LM301A op amp compares the sensed voltage from the overcurrent circuit with the precision reference (-5.1 V).

4.7.1.6 **Ramp Generator** – The conversion of error amplifier output to a current level is accomplished by the ramp generator. The error current charges a 1000 pF capacitor to generate the desired voltage ramp (-6.8 V peak).

4.7.1.7 **Pulse Width Modulator (PWM)** – The 55 timer of the PWM provides the input for the base drive transistor (Paragraph 4.7.1.1). Pulse width varies with error voltage over the range of 0 to 25 μs. Figure 4-9 is a timing diagram for the PWM. When the clock pulse goes low, the PWM timer is triggered on and the 1000 pF capacitor starts charging. As shown in the diagram, base drive in the PWM starts when the clock signal falls to zero and ends when the capacitor is charged to -6.8 V. If the -5.2 V output increases above the precision reference level, the capacitor charges at a faster rate. Since the clock pulse is fixed (25 μs on and 25 μs off), base drive decreases proportionately with the increase in -5.2 V output to return this voltage to normal.

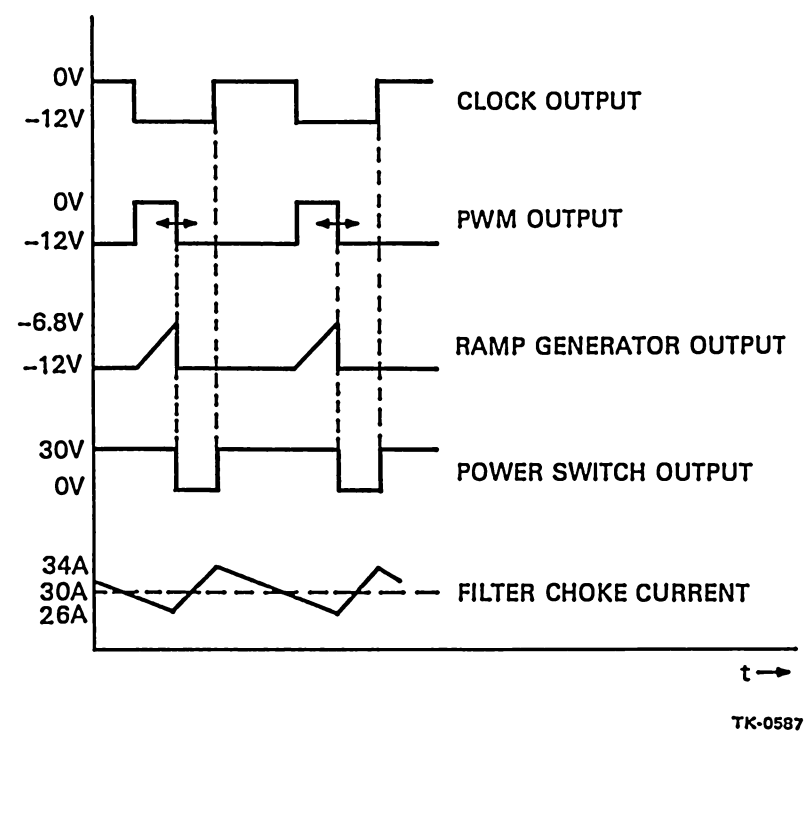

Figure 4-9 H7101 Regulator Timing Diagram

4.7.1.8 20 kHz Clock – The 20 kHz clock establishes the basic operating frequency for the –5.2 V regulator. A series resistor and capacitor connected to the control voltage input of an E555 timer provide for external sync by a signal originating at the clock (BC8) of the bias/control power supply on the B/C board. When the clock pulse at the buffered output goes high, the pulse width modulator (PWM) is triggered on.

4.7.1.9 Turn-Off-Drive Circuit – Rapid turn-off of the power switch transistors between conduction and reset is effected by a series-connected diode, 10 ohm resistor and 0.1 μF capacitor connected between the secondary and primary of the pulse transformer. When the power switch transistor is turned on, the capacitor is charging through the resistor. When the switch is turned off for the reset portion of the cycle, the capacitor generates a large reverse pulse on the base of the transistors to sharpen the turn-off transition.

4.7.1.10 Flyback Diode – A UES602 diode between the power switch and the LC output filter is reverse-biased when the power switches are turned on. When the switches turn off, the flyback diode is forward-biased and permits energy stored in the output filter to flow through the load for the duration of the reset interval.

4.7.1.11 DC OK Circuit – The DC OK circuit consists of a transistor switch and voltage divider. When the sensed dc at the overcurrent circuit approaches –4.95 V, the collector of the transistor goes high to generate a –5 V DC OK output. This signal is wire ORed with the +12 V DC OK and ±5 V DC OK signals at the input to the regulator-fail gate (BC28) on the bias/control board (Paragraph 4.6.3.5). When any of these failure-indicator signals goes low, the resultant high from the regulator-fail gate turns on the red Plug-In-Regulator-Failure lamp of the H7100 status display (Paragraph 3.4.3).

4.7.1.12 Crowbar – Load protection for the –5.2 V regulator is provided by two SCRs that turn on sequentially to apply a short circuit across the output when its voltage exceeds –6.5 V, maximum. Under short circuit conditions, (crowbar fired) H7101 output voltage falls to –0.8 V until the crowbar is turned off. If the main (power) switch transistors short circuit, the crowbar will turn on for this malfunction as well and, in addition, the 15 A fuse at the input to the base drive circuit will blow.

NOTE

Protection against the application of an external voltage to the output is not provided.

4.7.1.13 Voltage Reference – The precision voltage reference for the LM301A error amplifier is provided by a 1/4 M5.1AZ1 (5.1 V, 1 percent) zener diode and a 470 ohm series resistor fed by the –12 VA output of the bias/control power supply on the bias/control board (Paragraph 4.6.1 and Figure 4-7).

4.7.1.14 Slow Run-Up Circuit – Slow run-up of the precision reference for the error amplifier is provided by a paralleled 2.2 μF capacitor and 1 K resistor connected between pin 3 of the LM301A error amplifier and ground. Slow run-up minimizes overshoot of regulator output voltage during initial start-up and during recovery following a crowbar short due to an overvoltage condition.

4.7.2 H7102 (+12 V) Regulator

Figure 4-10 is a block diagram of the H7102 regulator. As seen, this regulator comprises:

1. Power switch
2. Power switch driver
3. Output filter
4. Overcurrent circuit
5. Error amplifier
6. Ramp generator
7. Pulse width modulator (PWM)
8. 20 kHz clock

9. Turn-off-drive circuit
10. Flyback diode
11. DC OK circuit
12. Crowbar
13. Voltage reference
14. Slow run-up circuit.

With minor differences, the purpose and operation of these regulator sections are the same as those described under heading of the H7101 (–5.2 V) regulator in the preceding subsection. However, for simplicity of reference and to point out any differences between the two regulators, the functional sections are as follows.

4.7.2.1 Power Switch – The power switch of the H7102 regulator uses a single transistor in conjunction with the pulse transformer to develop a duty-cycle-controlled pulsed-dc output in response to the closed-loop feedback circuitry for correcting sensed error voltage in the +12 Vdc output. The power switch is energized by the +30 V output from the 350 μh choke on the motherboard. The 1000 μF filter capacitor on the H7102 board is automatically connected across the unregulated +30 V output from the choke when the board is inserted into jack J2 on the motherboard. Line protection is provided by the 15 A fuse at the input to the power switch transistor. The input for the turn-off-drive circuit is taken from the secondary of the pulse transformer.

4.7.2.2 Power Switch Driver – The power switch driver uses two transistors whose turn-on is controlled by the buffered output signal of the 55 timer in the PWM. Transistor bias voltages are the +12 VA from the flyback power supply on the bias/control board. The base-drive transistors are turned on by the leading edge of the 20 kHz conduction pulse from the pulse width modulator. Also inputting to the base drive circuit through a normally reverse-biased diode is a +12 V regulator inhibit signal from the H7103 status and sequence circuit (Paragraph 4.7.3.4 and Figure 4-12). When this signal is generated upon failure of the ±5 VB input to the quad comparator, pulsing of the H7102 is inhibited.

4.7.2.3 Output Filter – The output filter consists of a 250 μH choke and a 1500 μF capacitor.

4.7.2.4 Overcurrent Circuit – Current limiting in the overcurrent circuit is provided by a 0.01 ohm resistor in series with the 250 μH choke of the output filter. The current through this resistor and the voltage across it is triangular in shape and rides on the average dc output current. The monitored peak choke current is approximately 13 A peak-to-peak. The current limit for the +12 V output is set at 12 A.

4.7.2.5 Error Amplifier – In the error amplifier, an LM031A op amp compares the sensed output voltage with the precision reference. The resultant error amplifier output voltage is fed to the ramp generator.

4.7.2.6 Ramp Generator – Error amplifier output is converted to a current level in the ramp generator. This error current charges a 1000 pF capacitor in the collector circuit of the ramp generator to establish the desired voltage ramp (+5.1 V peak).

4.7.2.7 Pulse Width Modulator (PWM) – A 555 timer in the PWM provides (from its buffered output) the input signal for control of the base drive transistors in the power switch driver (Paragraph 4.7.2.2). Pulse width varies with error voltage over the range of 0 to 25 μs. Figure 4-11 is a timing diagram for the PWM. When the clock pulse goes low, the PWM timer is triggered on and the 1000 pf capacitor connecting the clock timer and the PWM timer starts charging. As shown in the diagram, base drive in the PWM starts when the clock signal falls to zero and ends when the capacitor is charged to 5.1 V. If the +12 V output increases above the precision reference level, the capacitor charges at a faster rate. Since the clock pulse is fixed (25 μs on and 25 μs off), base drive decreases proportionately with the increase in +12 V output to return this voltage to normal.

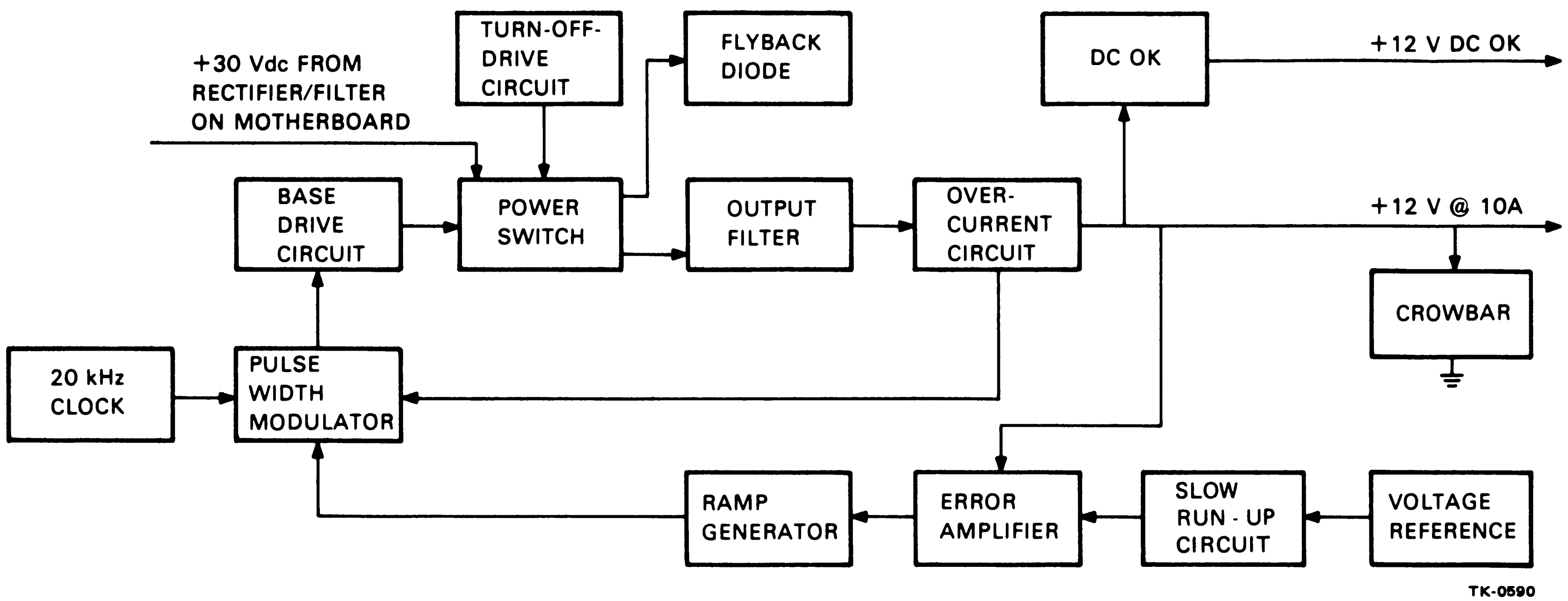

Figure 4-10 H7102 (+12 V) Regulator Block Diagram

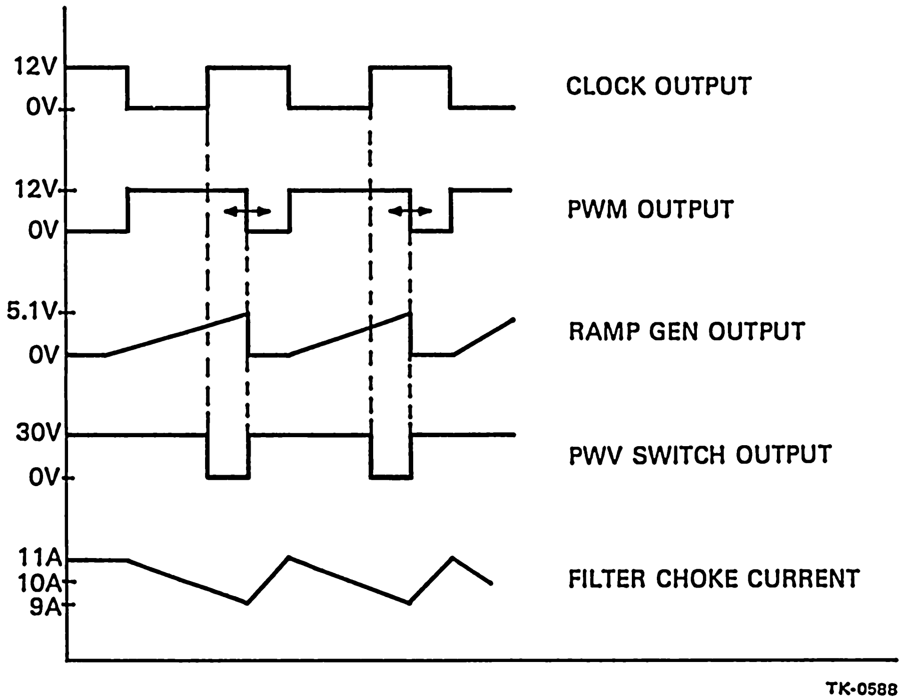

Figure 4-11 H7102 Regulator Timing Diagram

4.7.2.8 20 kHz Clock – The clock establishes the basic operating frequency of the +12 V regulator. A series resistor and capacitor connected to the control voltage input of an E555 timer provide for external sync by a signal originating at the clock (BC8) of the bias/control power supply on the B/C board (Paragraph 4.6.1.8 and Figure 4-7). When the clock pulse at the buffered output of the clock timer goes low, the pulse width modulator is triggered on.

4.7.2.9 Turn-off-Drive Circuit – Rapid turn-off of the power switch transistor between conduction and reset is effected by a series-connected diode, 100 ohm resistor and 0.1 μF capacitor connected between the secondary and primary of the pulse transformer. When the power switch transistor is turned on, the capacitor is charging through the resistor. When the switch is turned off for the reset portion of the cycle, the capacitor generates a large reverse pulse on the base of the transistor to sharpen the turn-off transition.

4.7.2.10 Flyback Diode – An 11-10715 diode between the power switch and the LC output filter is reverse-biased when the power switch is turned on. When the switch turns off, the flyback diode is forward-biased and permits energy stored in the output filter to flow through the load for the duration of the reset interval.

4.7.2.11 DC OK Circuit – The DC OK circuit consists of a transistor switch and voltage divider. When the sensed dc at the overcurrent circuit approaches +11.4 V, the collector of the transistor goes high to generate a -5 Vdc OK output. This signal is wire ORed with the +12 Vdc OK and ±5 Vdc OK signals at the input to the regulator-fail gate (BC28) on the bias/control board (Paragraph 4.6.3.5). When any of these failure-indicator signals goes low, the resultant high from the regulator-fail gate turns on the red Plug-In-Regulator-Failure lamp of the H7100 status display (Paragraph 3.4.3).

4.7.2.12 Crowbar – Load protection for the +12 V regulator is provided by two SCRs that turn on sequentially to apply a short circuit across the output when its voltage exceeds 14.1 V, maximum. Under short circuit conditions, (crowbar fired) H7102 output voltage falls to 0.8 V until the crowbar is turned off. If the main (power) switch transistor short circuits, the crowbar will turn on and the 15 A fuse at the input to the base drive circuit will blow.

NOTE

Protection against the application of an external voltage to the output is not provided.

4.7.2.13 Voltage Reference – The precision voltage reference for the LM301A error amplifier is provided by a 1/4 M5.1AZ1 (5.1 V, 1 percent) zener diode and a 330 ohm series resistor fed by the +12 VA output of the bias/control power supply on the bias/control board (Paragraph 4.6.1 and Figure 4-7).

4.7.2.14 Slow Run-Up Circuit – Slow run-up of the precision reference for the error amplifier is provided by a transistor whose base voltage is provided by a voltage divider with +12 V source. This arrangement charges a 68 μF capacitor slowly between pin of the LM301A error amplifier and ground. Slow run-up minimizes overshoot of regulator output voltage during initial start-up and during recovery from a crowbar short.

4.7.3 H7103 (±5 B) Regulator

The H7103 (refer to the block diagram, Figure 4-12) comprises:

1. A +5 VB* switching regulator
2. –5 VB series regulator with 3-terminal output regulator
3. 12 V bias power supply
4. Status and sequencing circuit.

Under normal power-up conditions, the H7103 receives input power from both the +30 V and floating 30 V power sources on the motherboard. Bias voltages (+12 VA and –12 VA) are supplied from the bias/control power supply on the bias/control board. Under normal power-up conditions, the H7103 delivers +5 V at 20 A and –5 V at 0.2 A.

Under power-fail conditions, the H7103 (like the H7102) regulator receives its input power from the 36 V battery pack of the H7112 memory battery backup power supply. Under these conditions, the –5 VB power output remains the same (–5 V at 0.2 A), but the +5 VB and +12 VB capabilities are reduced to 18.5 A and 4.6 A, respectively.

4.7.3.1 +5 VB Regulator – The +5 VB regulator circuit on the H7103 board consists of:

1. Power switch and base drive circuit
2. Output filter
3. Overcurrent circuit
4. Error amplifier
5. Ramp generator
6. Pulse width modulator (PWM)
7. 20 kHz clock
8. Crowbar
9. Turn-off-drive circuit
10. Voltage reference
11. Slow run-up circuit.

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*The "B" designation indicates battery backup for this output. Voltages with an "A" suffix originate in the bias/control power supply.

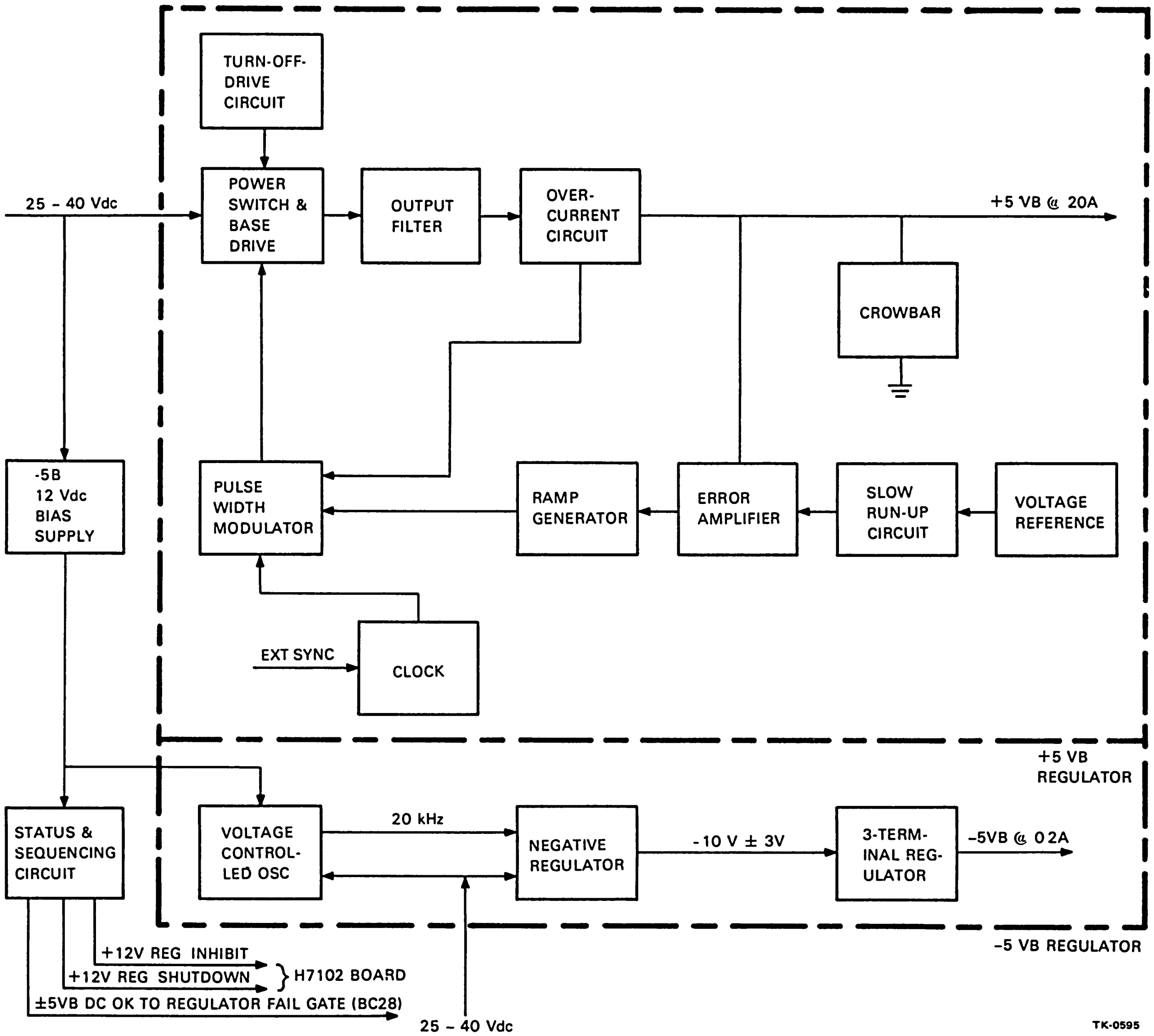


Figure 4-12 H7103 (+5 B) Regulator Block Diagram

Power Switch and Base Drive Circuit

The power switch and base drive circuit consists of two power-switch transistors, pulse transformer, balun transformer and two base-drive transistors. When one of the base drive transistors is turned off and the other one turned on, the voltage across the secondary of the pulse transformer reverses, causing the two power-switch transistors to turn on. The balun transformer forces these two transistors to share the current. If the base drive signal from the PWM becomes narrower (error voltage hasdecreased), the power transistors will not remain on as long, thereby reducing the average value and reducing the output voltage of the regulator. A flyback diode permits the filter choke of the output filter to continue delivery of output voltage when the power switch transistors turn off.

Output Filter

The output filter of the +5 VB regulator consists of a 25 μH choke and 15,000 μF capacitor.

Overcurrent Circuit

In the overcurrent circuit, current limiting is provided by two resistors in series with a 25 μH choke in the +5 VB output circuit, an arrangement that permits monitoring of peak choke current (approximately 6 A peak-to-peak). The current through the two (paralleled) resistors and the voltage across them is triangular in shape and rides on the average dc output current. The current limit for the +5 V output is set at 24 A.

Error Amplifier

In the error amplifier, an LM301A op amp compares the sense voltage with the precision reference (+5.1 V) and generates an amplified error output that is converted to a current level.

Ramp Generator

The conversion of error amplifier output to a current level is accomplished by the transistor of the ramp generator. This current charges an 8200 pF capacitor to generate the desired voltage ramp (8.0 V peak).

Pulse Width Modulator

The 555 timer of the PWM provides the input for the base drive transistor. Pulse width varies with error voltage over a range of 0 to 25 μs. Figure 4-13 is a timing diagram for the PWM. When the clock pulse goes high, the PWM timer is triggered on and the 8200 pF capacitor starts charging. As shown in the diagram, base drive in the PWM starts when the clock signal falls to zero and ends when the 8200 pF capacitor is charged to 8.0 V. If the +5 B output voltage increases above the precision reference level, the capacitor charges at a faster rate. Since the clock pulse is fixed (25 μs on and 25 μs off), base drive decreases proportionately with the increase in +5 B output voltage to return this voltage to normal.

20 kHz Clock

The +5 B (20 kHz) clock establishes the basic operating frequency for the +5 B regulator section. A series resistor and capacitor provide for external sync by a signal originating at the clock (BC8) of the bias/control power supply on the B/C board. The 20 kHz operating frequency is developed by the output of a 555 timer in the clock circuit.

Crowbar (Over-Voltage) Circuit

Load protection for the +5 B regulator is provided by two SCRs that turn on sequentially to apply a short circuit across the output when its voltage exceeds 6.3. Under short circuit conditions (crowbar fired), output voltage falls to 1.5 until the crowbar is turned off. If the main (power) switch transistors short circuit, the crowbar will turn on, and fuse F1 at the input to the regulator board will blow.

NOTE

Protection against the application of an external voltage to the output is not provided.

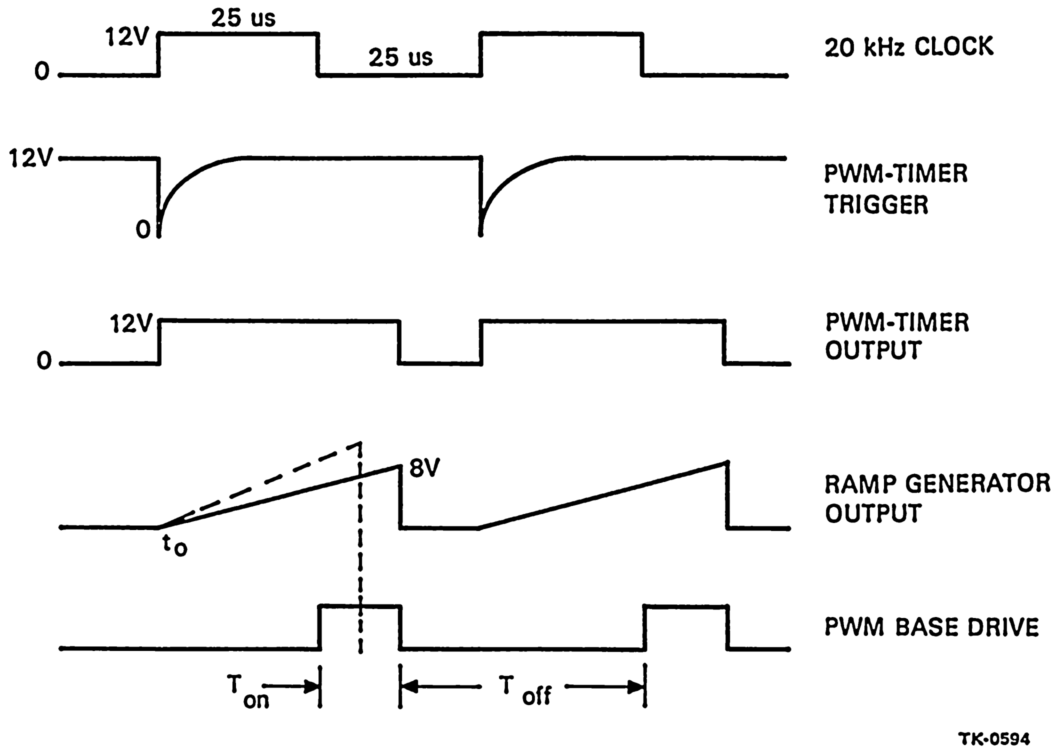


Figure 4-13 PWM Timing Diagram for +5 V Switching Regulator of H7103 Board

Turn-Off Drive Circuit
Rapid turn-off of the power switch transistors between conduction and reset is effected by a series-connected diode, 100 ohm resistor and 0.1 μF capacitor connected between the secondary and primary of the pulse transformer. When the power switch transistor is turned on, the capacitor is charging through the resistor. When the switch is turned off for the reset portion of the cycle, the capacitor generates a large reverse pulse on the base of the transistors to sharpen the turn-off transition.

Voltage Reference
The 5.1 V, 1% precision voltage reference for the LM301A error amplifier is provided by a zener diode in series with a 330 ohm resistor fed by the +12 V regulated output of the H7102 board.

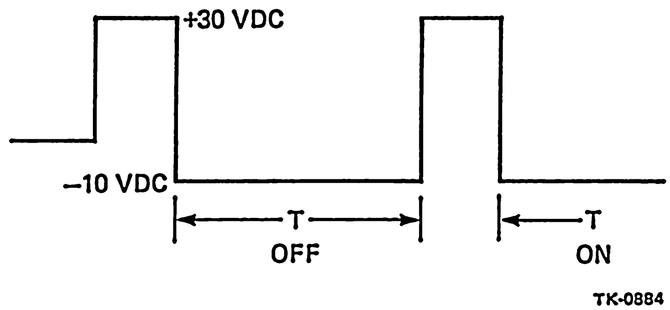
Slow Run-Up Circuit
Slow run-up of the precision reference for the error amplifier is provided by a 39 μF capacitor which, with the zener diode for precision reference, is connected between pin 3 of the LM301A op amp and ground.

4.7.3.2 –5 VB Regulator
The –5 VB regulator section comprises:

1. A voltage controlled oscillator (VCO)
2. Negative regulator
3. Three-terminal regulator.

Voltage Controlled Oscillator
The VCO determines the basic operating frequency (20 kHz ± 2 kHz) of the -5 VB section. Pulse ON time is 13 μs when the raw dc is 25 V and 6.5 μs when it is 50 V. Pulse OFF time is fixed at 39 μs. These parameters keep the energy in the associated 400 μH choke constant and the input voltage to the 3-terminal regulator constant at approximately -10 V.

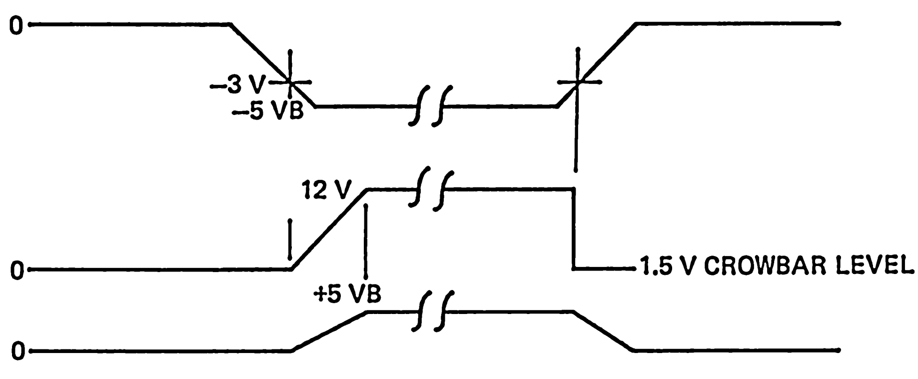
The negative regulator develops the -10 ± 3 V required by the 3-terminal regulator across a 50 μF capacitor connected between the input to this device and ground. For a raw dc voltage of 25 to 50 V, the waveform at the output of the pass transistor in the -5 V regulator circuit is:



3-Terminal Regulator
The 3-terminal regulator of the -5 VB section holds the -5 V output constant within ±5 percent, and provides its own internal protection. Overcurrent for the pass transistor of the negative regulator is provided by a 0.5 ohm current sensing resistor in series with the 400 μH choke. An overcurrent condition causes the 555 timer of the VCO to turn off until the start of a new cycle.

4.7.3.3 12 V Bias Supply for -5 VB Regulator
The 12 V bias supply provides the start-up potential for the -5 VB regulator and the status and sequencing circuit.

4.7.3.4 Status and Sequencing Circuit
The status and sequencing circuit uses an LM339 quad comparator to sense the availability of -5 VB and, indirectly, the +5 VB and +12 VB. The timing sequence for the -5 VB, +5 VB and +12 VB regulators is:



As shown in the block diagram of Figure 4-12, the following sequencer outputs are provided:

1. +12 V regulator inhibit (to the power switch driver of the H7102 regulator board)

2. +12 V regulator shutdown (to the crowbar external input of the H7102 board)

3. ±5 V DC OK (to the regulator-fail gate, BC28, of the bias/control board; refer to Figure 4-7 and Paragraph 4.6.3.5).

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APPENDIX A
GROUNDING

The following material on DIGITAL's current grounding practices comprises Chapter 3 (GROUNDING) of a forthcoming revision to the Digital Site Preparation Guide (EK-CORP-SP-001). Its inclusion here is for the convenience of personnel concerned with grounding as this affects VAX system installations.

A.1 INTRODUCTION
An important part of site preparation is to ensure that both the power and earth reference distribution comply with DIGITAL's requirements. The successful installation of a computer system requires pre-installation planning and careful attention to the details of the group distribution. This need should be approached by viewing the complete system in its physical and electrical environment. A properly planned site should include a diagram of the physical layout and an electrical diagram of the power and earth reference distributions.

A.2 GROUND DEFINITION AND PURPOSES
The word "ground" as used within an electrical connotation means "a connection to the earth for conducting electrical current to and from the earth" (definition from IEEE No. 81). In recent years, this definition has been expanded to include the need to establish a reference potential. There are two purposes for establishing an earth connection to equipment and systems.

1. Safety – to prevent a shock hazard in the event that an equipment chassis frame or housing develops a hazardous voltage due to lightning or an accidental breakdown of wiring or components.

2. Electromagnetic compatability – to reduce susceptibility interference equipment chassis are earth referenced at one common point.

A.2.1 Safety
The ac power distribution is governed by local, national and international regulations which deal with standards on wiring and other electrical requirements. All codes generally require the use of a safety (grn, grn/yl) conductor for electrical equipment. The requirement, generally stated, is that each hot (phase) and return wire (neutral) from a power source to a piece of equipment be accompanied by a safety conductor. The size of the safety conductor should be equal to that of the hot wire. This same requirement applies for all power systems (i.e., split-phase delta, wye, etc). Safety codes will generally require that the safety ground conductor be connected to any conducting surface that an operator can touch on the electrical equipment and can be energized by an electrical fault. This wire, under normal operation, should not carry 50/60 cycle ac return current. If the hot (phase) wire of a piece of equipment were accidently shorted to the frame, the frame of the equipment would then become raised to some hazardous voltage. If someone were touching that frame, their body could become the current path to earth ground. These safety shock hazards can be avoided by bonding the grn/yl safety ground wire to the equipment chassis. In this case, when a fault occurs within the equipment, the safety wire acts as the return path providing a very low impedance connection, and causing the circuit protection device (fuse or circuit breaker) to trip. All DIGITAL equipment having a power cord leaving a cabinet has the green/yellow safety conductor from the ac power cord connected to the chassis.

To help reduce line conducted electromagnetic interference, filters are often used at the power line entry of electronic equipment. Capacitors in these filter networks may be placed from both hot and neutral lines to ground to decouple (shunt) radio frequency interference (RFI). As a result there is a small leakage current in the grn/yl safety conductor. Various national and international organizations limit the size of such capacitors by placing a limit on the resultant reactive current flowing in the grn/yl safety wire. DIGITAL is currently limiting the reactive current to 3.5 mA per cabinet power controller cord in new equipment.

Another aspect of the safety problem involves providing a low-impedance path to earth in order to protect personnel and equipment during lightning strokes in an electrical storm. The purpose of lightning protection therefore, is to dissipate lightning energy in earth. When an ionized column of lightning strikes, it will seek out higher-elevation, sharp surfaces and low impedance paths from earth. To attain protection, lightning rods may be placed on the top of buildings to attract the stroke and dissipate the energy pulse into the earth.

However, depending upon where a building is located geographically, lightning protection may or may not be employed. In any event, building steel (vertical and horizontal beam lattice networks) is usually grounded providing minimum lightning protection. If the steel structure is not well earthed, the stroke current may divide between the structural steel and safety wiring if attached inadvertently. This means that a building's steel structure and/or internal wiring becomes a natural path for the lightning current pulse to follow. This is an important consideration and close attention should be paid when laying out the power ground distribution of the computer system. Figure A-1 depicts the potential problem that can occur if a system is inadvertantly "grounded" to a building frame. This is also in contradiction with the single-point ground scheme that will be explained in Paragraph A.4.2.

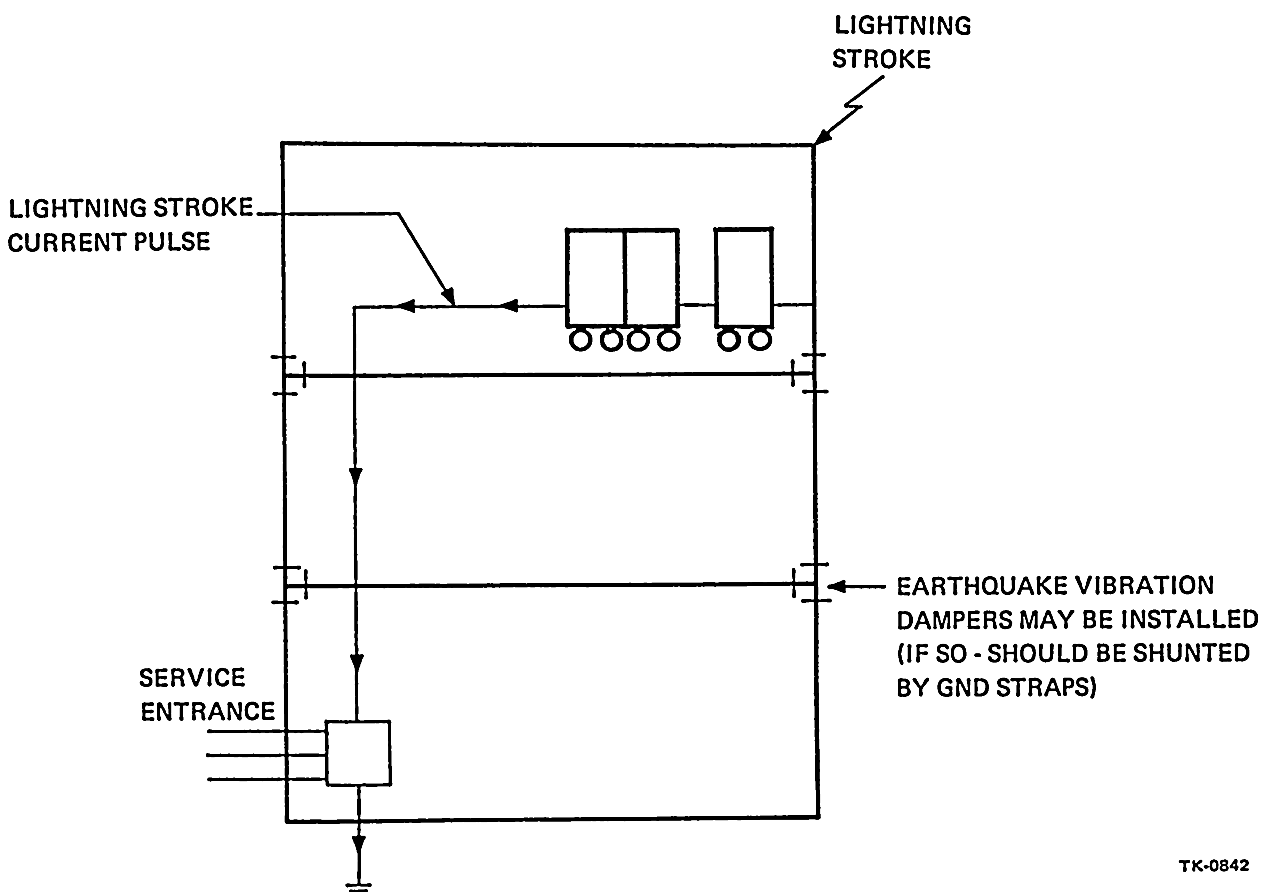

Figure A-1 Lightning Stroke Current Path (Shown with System Grounded to Building Steel)

A.2.2 Electromagnetic Compatibility

To accomplish interference compatibility through an effective grounding system, both system electrical components and cabinet frames should be maintained at the same reference potential. This is accomplished by providing a single, common reference point for each system cabinet and each subsystem logic reference in the system.

The purpose of this scheme is to make the system less susceptible to the flow of RF (radio frequency) currents including static discharge. Any two points on a cabinet or system of cabinets may develop a potential difference at some frequency; it is therefore essential to provide a low impedance path to shunt interference current back to ground, thus circumventing the susceptable areas of the system.

Static discharge, whether radiated from a nearby point or conducted directly onto the cabinets themselves, is a prime source of interference currents. Other sources of interference currents are flourescent lamp noise, harmonics from ac power mains, and line conducted impulses from machinery.

Virtually all electrical equipment may create noise on power lines when operating; computer systems are no exception. To mitigate this type of interference, filters are placed at the power line entry of computers. In this way, RF noise generated from nearby sources, can be shunted to earth ground.

A.3 SAFETY GROUND CONSIDERATIONS

The ultimate goal of any equipment grounding is to ensure personnel safety.

To be effective, safety connections must provide a low-impedance path at power frequencies to earth. An ideal ground reference would be a zero-potential, zero-impedance system that could be used as a reference for both power and signal reference. This would allow all undesirable signals and ambient radiation to be diverted to it. Ideally, it should be able to absorb all signals and radiation while remaining stable. This is the foundation for obtaining reliable, interference-free equipment operation and all of the inherent shielding qualities of the cabinetry.

Because of its multiple function – safety being the most important – all safety ground circuits must be carefully treated. The system's safety ground must be routed with the ac power conductors back to the power system transformer. The safety conductor may be insulated from conduit and other connections back to this point. The power transformer reference point must then be terminated at a low resistance earth connection.

In its path from the DIGITAL cabinets to the transformer earth reference the grounding conductor should not connect to:

- The ac neutral – this connection should be made only at the transformer or service entrance
- Grounds from equipment which is not part of the computer system
- Metal structural grounds, building steel, water pipes, etc.

A.3.1 Earth Ground Reference

This section discusses the techniques in establishing earth grounding reference systems that are compatible with requirements of various structure types.

This simplest and somewhat misleading idea of a good "ground" for an electrical system is a section of iron pipe driven into the earth with a wire conductor connected from the pipes, and pipelines historically have been an excellent media for connecting structural steel and power distribution systems to earth. This has been due to the large amount of surface area exposed to the earth and relatively large depths to prevent freezing when such piping is buried. It has been standard practice for many years to bond metallic structures above ground to water and gas pipes by means of copper bonds or copper ground rods. Unfortuantely, copper in its various forms creates an undesirable coupling of dissimilar metals: When in contact with iron or steel, copper will act as a cathode to accelerate corrosion, thereby increasing the bond inpedance in time. Due to both the resultant corrosion and economics of under-

ground piping systems, utility companies are leaning toward coated pipes or non-conductive pipes and couplings which will eliminate this widely used method of grounding. This may, therefore, be an unsuitable path for electrical current to flow (if a fault occurs) to protect personnel and equipment. Thus to establish an effective, noise free ground (earth reference) it may be necessary to install dedicated grounding systems for all large computer installations. Resulting from the need for dedicated grounding systems, it becomes necessary to utilize ground stakes and meshes.

A.3.1.1 Earth Ground Stake(s) – A practical earth electrode that provides a low ground resistance is not always easy to obtain. Earth resistivity has an important bearing on resistance, as does depth, electrode size and earth salt content. It is beyond the scope of this guide to go into great detail about any of these parameters. It is mentioned, however, to give insight into the necessary considerations.

Current in a grounding system is primarily determined by the leakage current during normal operation of the electrical equipment. This current should, for safety reasons, be limited and is governed under various national and international standards. The effectiveness of a safety ground system (Figure A-2) is determined by its ability to shunt fault current to ground. To accomplish this, the resistance of the grounding system must be very small. Three components that constitute the resistance of the grounding systems are:

1. Resistance of the conductor connecting to the ground stake.
2. Contact resistance between the ground stake and the soil.
3. Resistance of the body of earth immediately surrounding the ground stake.

A.3.1.2 Earth Ground Grid Meshes – Ground-grid meshes are often required to complement rods or can be used seperately when deep-driven rods are impractical due to soil and terrain considerations. Grounding resistance can be reduced significantly below that of the earth stake by buried grid meshes. Increasing the number of grids and/or the area of grid coverage can also significantly lower the ground resistance.

Ground rod and grid-mesh criteria developed in these sections can be realized for effective implementation in extremely rocky or frozen soil, when deep penetration of ground rods is impractical. In such cases ground grids may be used. However, in regions subjected to extreme climatic variations, earth resistivity will vary considerably causing resistance changes in shallow buried grid meshes. In various localities with dry soils, earth resistivity may be extremely high regardless of the depth of the ground rod penetration. In situations such as these, other techniques may be utilized to obtain necessary lowground resistance: impregnation of soil with salt solution, immersion of grid or plate in nearby water sources.

A.4 GROUNDING REQUIREMENTS

To keep electrical noise under control and preserve system integrity, the safety ground system described in the following paragraphs is recommended. Other schemes may also provide adequate grounding; however, any alternate system should be carefully studied to ensure that compatible grounding is provided.

A.4.1 Primary Power Distribution

The primary power feeder for the entire system (including all external components such as terminals, other systems in direct communication, laboratory data collection equipment, etc.) should be unique to the system. All power, therefore, for all system related components should be derived from the same system distribution panel. In some cases, however, this may not be possible. Various reasons for not using a unique system power feeder include:

- The new computer system required more power than one feeder could deliver.
- The new computer system communicates with another existing system which does not have enough reserve power to power the new system, or the power is incompatible (voltage/frequency).

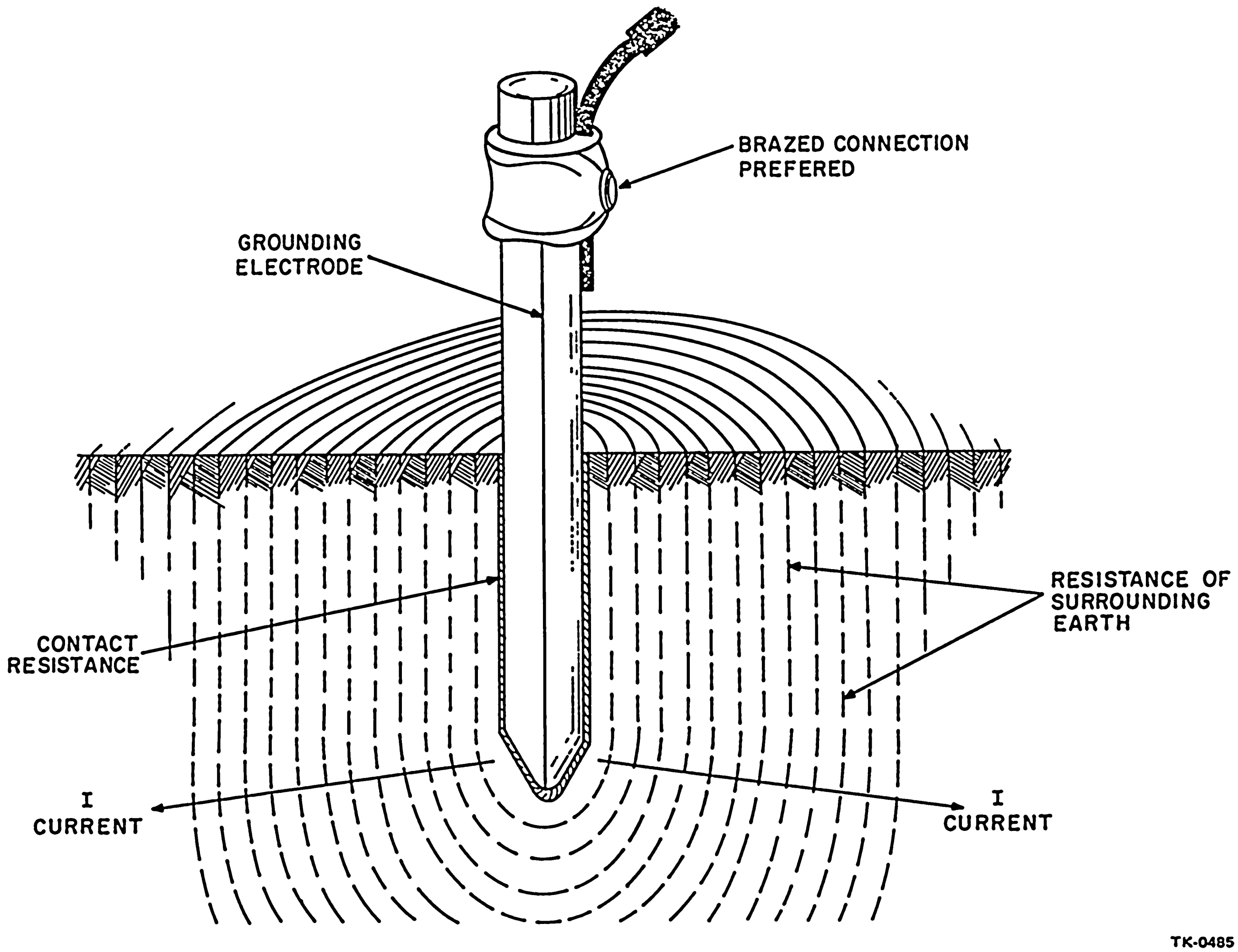

Figure A-2 Earth Ground Stake
(Ground Rod)

- The new computer system is distributed over a very large area such that branching from a single distribution panel is impractical.

In any of these cases, it must be assured that both power distributions are referenced together and that each power reference point is at the same potential.

A.4.2 Power Reference Distribution

Since there is a need to reference individual subsystems to power line ground for safety reasons, all DIGITAL computer cabinets containing a subsystem contain a power controller (861, 866, 869, etc.).

The power controller is the power distribution for all subsystems within a cabinet and is not designed to power external devices. The ac power cord for the power controller contains a separate insulated grn/yl conductor for the safety ground and the connection to the equipment chassis is made within the controller. This conductor must then be connected to the system earth reference. All electrical outlets providing power for a system, shall have a safety wire, (grn/yl), connected between the receptable ground connection and the system earth reference within the distribution panel. These wires should be isolated from all other connections (including building steel). When power wiring is run in either

conduit or armored cable (Bx) between the receptable and power distribution panel, it may be necessary to install Isolated Ground Receptacles. These receptacles are designed to isolate the safety conductor (grn/yl wire) from the metallic box. This will then effectively isolate the system safety ground from external noise sources (fault currents) back to the system earth reference. The system earth reference will then be connected to the safety earth ground at one point (refer to Figure A-3, Ground Reference Distribution).

For small data processing systems requiring only one receptacle, the system earth reference can be identified as the connection within the receptacle. For larger systems requiring a customer power distribution panel, the system earth reference will be identified as the junction where all of the grn/yl safety wires are common within the panel.

A.4.2.1 Testing the System Earth Reference – A convenient means should be provided to verify that the entire system is indeed referenced to earth at one and only one point (the system earth reference point). It is necessary that this point be will defined, and labeled. It should additionally have a means of disconnection (single stud/lug) whereby this reference can be lifted and the system tested to determine if there is any point other than this point at which the system is referenced to earth.

Two tests can be performed which will verify the proper isolation of the system reference point. These tests should only be performed with the assistance of an electrician.

1. With power applied to the system, measure the current in the system earth return wire. This measurement should be made with a device which can measure current without disconnection of the wire (a clamp-on ammeter). The maximum current in the system earth return should not exceed 3.5 mA (for new equipment) for every power cord exciting a cabinet in the system. Current in excess of this amount indicates improper primary power/reference distribution, and should be investigated before continuing.

2. Remove all primary power to the system. This may be accomplished by either:

   - Opening dedicated system circuit breakers at the customer's power distribution panel.

   - For smaller systems not requiring a dedicated power panel, unplugging the ac power cord is sufficient.

Disconnect the system earth return from the safety earth ground bus (Figure A-3). There should be a minimum of 100 ohms resistance between the system earth reference and the safety earth ground bus measured at dc.

WARNING

When the system earth reference is removed from the primary or dedicated safety earth ground bus, there may exist hazardous voltages between the system earth return wire and the safety earth ground bus. This wire should thus be handled accordingly. Before any resistance measurements are made that require the disconnection of this return wire, the voltage between the system earth return wire and the safety earth ground bus should be measured to determine if a hazardous condition exists.

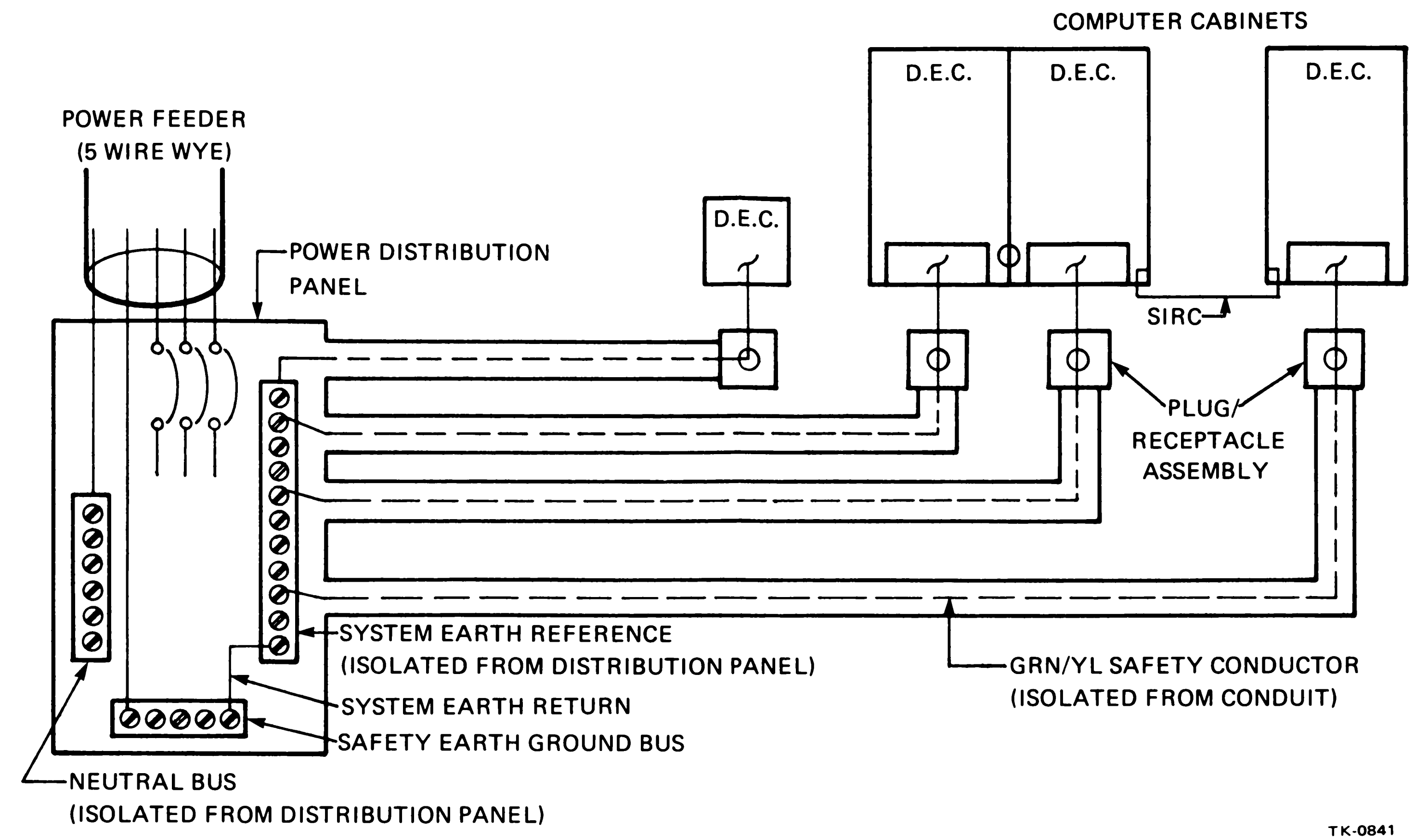

Figure A-3 Ground Reference Distribution

A.4.3 Inter-Cabinet Connections

Each cabinet of the system is provided with ground lug terminals. Upon installation, cabinets that are bolted together also should be electrically bonded with a ground braid strap or stranded copper (#10 AWG) conductor. Systems that are configured with standalone cabinets or separate groups of cabinets must also maintain chassis ground for signal integrity. In this case, the ground lugs should be connected via a #4 AWG (5 mm, 0.20 inch) insulated copper wire or standard #4 AWG insulated welding cable of the same size. This signal integrity reference cable (SIRC) should be as short as possible and dressed along the data cable path.

All free-standing mass-storage devices must also be referenced to the system unless metallic troughs are used which connect cabinet chassis together. For this reason, the SIRC must be installed. This cable should also be routed close between 15-50 cm (6-20 inches) to the data cable to reduce ground loop area, and connected to the cabinet containing the drive controller. A Burndy QA4C-B solderless lug (or equivalent) may be used for termination.

A.4.4 Raised Floors

A raised floor is generally a desirable feature. For safety purposes, the floor grid, being either separate pedestals or pedestals with rail construction should be grounded. This can best be achieved by connecting the floor grid to the safety earth ground bus in the distribution panel. It must be understood that when it is attached to this point, it must be isolated from building steel, electrical conduit, air-conditioning duct, etc. If this is not accomplished, sneak paths for external currents and EMI may contaminate the system reference.

A.4.5 Customer Convenience Outlets or Devices

It is recommended that any customer convenience devices, e.g., coffee pots, vacuum cleaners, electric typewriters, etc., receive their power from a branch circuit independent from that powering the system. This branch circuit may be taken from the same primary power source as the system without adverse effects. The intent is to ensure that the system earth return does not carry earth return currents from the customer convenience devices.

APPENDIX B
H7100 POWER SUPPLY AND REGULATOR REPLACEMENT

Replacement of the H7100 dc power supply or reconfiguration of its regulator complement can be accomplished in the field with the following parts from the VAX-11/780 CD kit:

1. One configurable H7100 dc power supply (includes the bias/control board and provides +5.1 V output)

2. One 5412560 H7101 -5.2 V regulator board

3. One 5412556/5412558 H7102/H7103 +12 V/±-5 VB regulator board.

Corrective maintenance guidelines for the H7100 are:

Regulator Failure
If the 5412560, 5412556 or 5412558 fail, replace the failed board with board from the CD kit.

Basic H7100 Failure
If the basic H7100 fails, replace it with the H7100 from the CD kit.

H7100 Fails, But Its Regulators are Good
If the basic H7100 fails, but its regulators are still good:

1. Remove regulators from failed H7100.

2. Insert the removed regulators in the H7100 of the CD Kit.

3. Remove the blank jack J6/J7 from the new supply.

4. Use cables from the failed supply to connect up regulators (Figure B-1); install J6 or J7 in rear panel cutout.

5. Use insulator boards from failed supply.

6. Attach appropriate decals at rear of supply to show regulator configuration (Figures 3-31 and 3-32).

   Decal 3614762-00 – H7100 Power Supply with H7101 Regulator Board.

   Decal 3614762-01 – H7100 Power Supply with H7102 and H7103 Battery Backup and Regulator Board.

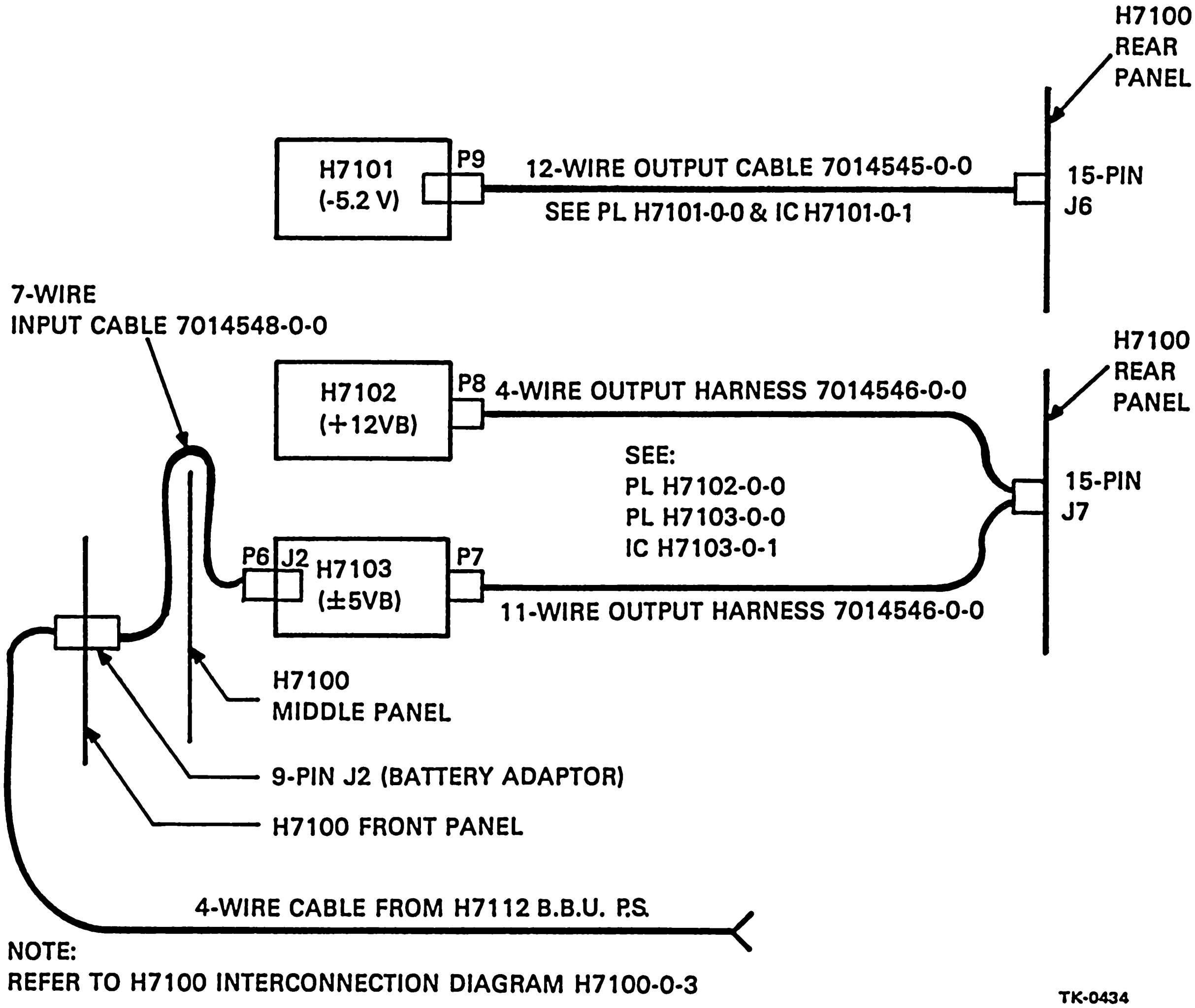

Figure B-1 Basic H7100 DC Power Supply, Regulator Boards, Cables and Harness for Corrective Maintenance on Failed DC Supply

If replacement cable or harness are needed, order separately (they do not come with kit):

7014545-0-0 – Output cable, 12-wire for H7101 board

7014546-0-0 – Output harness, 4-wire/12-wire for H7102/H7103 boards

7014548-0-0 – Input cable, 7-wire, for H7103 board

1700021-04 – Insulator board (electromagnetic shield).

VAX-11/780 POWER SYSTEM
TECHNICAL DESCRIPTION
EK-PS780-TD-001

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